PART ~~8~~3B

GENERAL MECHANICAL REQUIREMENTS

Contents

3.1 8.1 Wet Wells.....3

3.2 8.2.....Dry Pit Pumps 4

38.2.1 General.....4

38.2.2 Features of Construction.....56

38.3 .....Submersible Pumps 57

83.3.1 General.....57

83.3.2 Features of Construction.....68

8.4.....Chemical Feeding Equipment 1412

8.4.1.....Chemical Dosing Pumps 1412

Chemical Tank and Mixer.....1513

8.4.2.....Alum Dispersion Rapid Mixer 1614

38.5 Induction Motor (Dry pit Sewage / Sludge Pumps) 79

38.54.1 .....Design Requirements 79

83.54.2.....Performance and Characteristics 89

83.54.3.....Insulations 810

83.54.4.....Constructional Features 810

83.54.5.....Terminal Box 911

83.54.6.....Accessories 911

83.54.7.....Heating during Idle Period 911

83.54.8.....Earthing Pad 911

83.54.9.....Rating Plate 911

83.54.10.....Tests 1112

83.54.11.....Low Voltage Motors 1212

83.65 .....Induction Motor (Submersible Pump) 1212

83.65.1.....Performance and Characteristics 1112

83.65.2.....Submersible Cable 1334

83.65.3.....Earthing 134
83.65.4.....Insulation 135
83.65.5.....Temperature Rise 145
83.65.6.....Constructional Features 145
83.65.7.....Terminal Box 145

8.73.6 .....Gate –controlled Weir 146

8.83.7 .....Sluice Gate 156

8.93.8 Heavy Duty .....Mechanical Coarse Bar Screen 187
83.98.1 .....
General.....17
8.93.8.2.....Frame work 178
8.93.8.3.....Screen bar assembly 178
8.93.8.4.....Rake carriage 179
8.93.8.5.....Rake Lifting Mechanism 189
8.93.8.6.....Inspection Platforms 189
8.93.8.7.....Dead plate 189
8.93.8.8.....Driving Mechanism 1820
8.93.8.9.....Gear Reducer 1820
8.93.8.10.....Control System 1820
8.93.8.11.....Conveyor System 1921
8.9.12 Portable Screenings Container.....20
8.93.8.132.....Motors 202

3.98.10 .....Mechanical Medium Bar Screen 212
3.98.10.1.....Construction 213

8.11.....Automatic Drum screen 22

8.12 Manual Medium Bar Screen 22

8.13 Manually Operated Travelling Crane 3432

8.13.1 Crane 3432

8.13.2 Trolley and Chain Pulley Block 3533

8.14 Electrically Operated Hoists 3634

8.15 Hand Operated Hoists and Trolleys 3634

8.16 Electrically Operated Overhead Travelling Crane 3735

3.108.17 Jib cranes 234

8.183.11 Grit Removing Equipment 234

8.193.12 Fine Bubble Tubular Membrane Diffusers 245

3.128.19.1 Diffuser Assembly 246

8.193.12.2 Air Header and Droplegs 246

8.193.12.-3 Supports and Anchors 247

8.19.4 Spare Parts 26

8.193.12.54 Installation 247

8.193.12.65 Field testing 247

8.193.12.76 Leakage and distribution of flow tests: 248

8.19.8 Disc Fine Bubble Aeration System 27

8.193.13.9 High Speed Turbo Air Blowers 278

8.19.101 Acoustical Enclosure 30

8.3.14 19.11 Submersible Mixer 2930

8.203.15 Primary and Secondary Clarifiers 2931

8.213.16 .....Gravity Thickeners 302

8.22.....Dewatering Centrifuges 34

8.23.....Conveyor System 36

3.178.24 Primary Sluge Pumps (.....Progressing – Cavity Pumps) 324

8.25.....Sludge Digester and Bio Gas Peripheral Equipment 5654

8.26.....Gas Holder (Single Stage Bell) 5957

8.27.....Bio-Gas Cleaning Equipment and Peripheral Equipment 6159

8.28.....Peripheral Equipment and devices for Bio-Gas application 6260

8.29.....Gas Compressors 6462

8.30.....Digester heating system 6563

8.30.1.....Hot Water Boiler 6563

8.30.2.....Digestion sludge Heat Exchanger 6866

8.30.3 Digester Mixing Equipment.....6866
8.30.4 Electrical equipment.....7068
8.30.5 Room for Boiler.....7068
8.31 Flare.....7169
8.32 Chlorination System.....7270

8.32.1.....Chlorinators 7270

8.32.2.....A: Motive water pumps and Injector 7270

8.32.3.....B: Inline vacuum induction type chlorine injectors 7371

8.32.4 Chlorine.....7371
8.32.5 The Tonner Room.....7371
8.32.6 Chlorination Room.....7472
8.32.7 Chlorine Leak Detectors.....7573
8.32.8 Ventilation System.....7674
8.32.9 Chlorine Residual Monitors.....7674

8.32.10 Safety Equipment 7775
8.32.11 Chlorination Power and Control 7876
8.33 Plant Drainage Pump set 7876

8.34 Fire Extinguishers 7977

8.35 Propeller Exhaust Fan 7977

8.36 Air-conditioning Equipment 7977

3.188.37 Valves 3534
8.373.18.1 Electric Actuator 3335
8.373.18.2 Sluice Valves 346
8.373.18.3 Knife Gate Valves 4037
8.373.18.4 Slide Gate Valve 4138
8.373.18.5 Non Return Valve 4238
8.373.18.6 Telescopic Valves 4239
8.373.18.7 Diaphragm Valves 4339
8.373.18.8 Isolating Cocks 3940
8.373.18.9 Pressure / Vacuum relief valves 3940
8.373.18.10 Adjustable Weir Plates 3940
8.373.18.11 Eccentric Structure Valve 3941

8.38 Domestic Water Pump sets 8684

3.198.39 Quality 3941

8.403.20 Warranty 3941

8.413.21 Pipelines, Pipe work and Fittings 402
8.43.21.1 Applicable codes 402
8.43.21.2 Materials 402

8.43.21.3 Code of Practice 413
8.43.21.4 Materials for Pipelines 413
8.43.21.5 Ductile Iron Pipes and Fittings 42
3.218.41.5.1 Pipes and Fittings 42
3.28.41.5.2 Joints 424
8.43.21.5.3 Linings 424
3.28.41.5.4 Coating 4445
8.42 Reinforced Cement Concrete Pipes 9189
8.42.1 Design 9189
8.43 Manufacturing 9290
8.43.1 General 9290
8.43.2 Materials 9290
8.43.2.1 Cement 9290
8.43.2.2 Aggregates 9290
8.43.2.3 Mixing and Curing Water 9391
8.43.3 Reinforcement 9391
8.43.3.1 Concrete 9391
8.43.3.2 Curing 9391
8.43.3.3 Dimensions 9391
8.43.3.4 Workmanship and Finish 9391
8.43.4 Testing 9492
8.43.4.1 Sampling and Inspection 9492
8.43.4.2 Marking 9593
8.44 Jointing 9593
8.44.1 General 9593
8.44.2 Spigot and Socket joint (Rigid) 9694
8.44.3 Collar Joint (Rigid) 9694
8.44.4 Flush Joint (Internal) 9694
8.44.5 Flush Joint (External) 9694
8.44.6 Spigot and Socket (Semi-flexible) 9795
8.44.7 Collar Joint (Semi-Flexible) 9795
8.44.8 Spigot and Socket Joint (Flexible) 9795
8.44.9 Cleaning of Pipes 9795
8.45 Testing at work site 9896

3.228.46 Steel Cylinder Pipes and Specials 4445
8.46.1 Design 445

8.47 Manufacturing 4466

8.47.1.1 General 56
8.47.1.2 Materials 56
8.47.1.3 Manufacturing Process 57
8.47.1.4 Dimensions 57
8.47.1.5 Workmanship and Finish 57
8.47.1.6 Testing 57
8.47.1.7 Penetration Test 58
8.47.1.8 Marking 58
8.47.1.9 Jointing 58
8.47.1.10 General 58
8.47.1.11 Butt Welded Joint 58
8.47.1.12 Lap Welded Joint with Slip in ends 59
8.47.1.13 Flanged Joints 59
8.47.2 Cleaning of pipes and specials 59
8.47.3 Testing at work site....59
3.23 8.48....Steel Pipe work 4950
8.48.1 Welded Joints for Steel Pipes....62
8.48.2 Welder Performance Test....63
8.48.3 Testing of Welded Joints....63
8.48.4 Hydraulic Losses....63
8.48.5 Pipe work Protection....64
8.48.5.1....External protection 64
8.48.6 Flexibility in Pipe work....64
8.48.7 Puddle Flanges....65
8.48.8 Small Bore Pipes and Hoses....65
8.48.9 Support of Pipe work and Accessories....65
8.49 Cast Iron Pipes....109107

8.49.1....Manufacturing **109**107
8.49.1.1....General 109107
8.49.1.2....Materials 109107
8.49.1.3 Dimensions....109107
8.49.1.4 Workmanship and Finish....110108
8.49.1.5 Testing....110108
8.49.1.6 Coating....111109
8.49.1.7 Marking....111109
8.50 Jointing....111109
8.50.1.1 General....112110
8.50.1.2 Tyton joints....112110
8.50.1.3 Flanged Pipes....112110
8.50.1.4 Cleaning of Pipes and Fittings....112110
8.50.1.5 Testing at work site....113111
8.51 Un plasticised PVC Pipes and Fittings....114112
8.51.1 Polyethylene Pipes....114112
8.51.2 Rubber Hosing....114112

8.51.3 Copper Tubes and Fittings.....114112
8.51.4 Flanged Joints.....114112
8.51.5 Gaskets and Joint Rings.....115113
8.51.6 Flexible Couplings and Flange Adaptors.....115113
8.52 Storage & Shipment.....116114
8.52.1 Protection of Pipes and Fittings for Shipment.....116114
8.52.2 Storage of Pipeline Materials.....116114
8.53 Transportation of Pipes and Fittings.....117115

8.54.....Inspection of Pipes and Fittings 117115

8.54.1.....Built in Pipe work and other Plant 117115

8.55.....Pipe laying 118116

8.55.1.....Carting & Handling 118116
8.55.2 Storage.....118116
8.56 Laying.....118116

8.56.1.....Excavation 118116

8.56.2.....Dewatering 120118

8.56.3.....Special Foundation in Poor Soil 120118

8.56.4.....Wooden Shoring 120118

8.56.5.....Steel Plate Shoring 121119

8.56.6.....Boning Staves and Sight Rails 121119
8.56.7 Laying of Pipes and Fittings/Specials.....122120
8.56.8 Thrust Blocks.....123121
8.56.9 Jointing.....123121
8.56.10.....Testing and Commissioning 123121
8.56.11.....Backfilling 123121
8.56.12 Reinstatement of Road/Footpath.....124122
8.56.13 Clearing of Site.....124122
8.57 Disinfection of Water Mains.....124122
8.57.1 Continuous Feed.....124122
8.57.2 Slug Method.....125123

PART 8

GENERAL MECHANICAL REQUIREMENTS

83.1 Wet Wells

(a) In order to prevent surcharging of sewers, the maximum level of sewage in the suction/wet well of the TSPS shall be limited to 300 mm below the invert of the lowest incoming sewer.

(b) For the TSPS, in order to prevent sewage from turning septic, maximum retention of sewage in the wet / suction well shall not exceed 30 minutes for the average flow.

(c) The depth of sump shall be such that it provides at least 15 % margin over the minimum required pump submergence calculated at duty point on the basis of the Hydraulic Institute Standard.

(d) The wet well effective operating volume (volume between low level where all pumps are shut off and high level where all pumps except standby are operating) shall be such that the hydraulic retention time in this volume at peak flow is not less than 5 minutes and the number of starts per hour does not exceed 2 for any single pump under any circumstances.

(e) Appropriate baffles shall be provided in the wet/suction well to prevent the excessive turbulence and air entrainment when free fall of material to be pumped occurs.

(f) Benching shall be provided at the bottom of the wet well towards the suction bell mouth to ensure that the pumps can be used to completely drain the wet well.

(g) The wet well design shall incorporate corner fillets and ogees as appropriate to eliminate dead spots, prevent accumulation of solids or debris, and to ensure that the wet well is fully self cleaning – automatically cleaned by the hydraulics of the flow.

(h) Priming of pumps shall be ensured by providing positive suction head.

(i) Operation of sewage pumps shall be automatic based on the sewage levels in the wet well.

(j) Standby unit of each type and size of pump employed shall be provided as specified in particular mechanical requirement and these shall be minimum requirement.

(k) The clearance between pumps outer periphery (or pump foundations) shall be not less than 1000 mm.

(l) Sequence of operation of raw sewage pumps shall be changed every 8 hours to avoid accumulation of solids in the wet/suction well.

(m) + 5% margin on the pump capacity shall be provided for all the pumps.

(n) The total head of the pump shall be selected considering peak flow and maximum design level in the wet well for normal conditions of operation, and checked for satisfactory operation under extreme conditions of operation; the selected head to be revised if required.

(o) The minimum permissible velocity in the pumping mains shall be 0.6 m/sec. Velocity of 1.2 m/sec shall be achieved by operating all sewage working pumps. The maximum velocity in the pumping main shall not exceed 2.5 m/sec.

(p) All dry well pumping stations shall be provided with a pit and drain pumps (1 working + 1 standby) to automatically empty the stuffing box drain.

(q) Ventilation shall be provided for the pumping station based on 10-12 air changes per hour.

(r) For TSPS, mechanical rake coarse bar screen shall be provided upstream of the pumping station wet well. Provisions shall be made to allow lifting of screenings by belt conveyor.

(s) Appropriate lifting devices shall be provided for safe and easy retrieval and/or removal of the pumps from wet well or dry well for maintenance or any other purpose at all pumping stations.

6.1 Dry Pit Pumps

6.1.1 General

The total head capacity curve shall be continuously rising towards shut off with the highest at shut off.

(a) Pumps shall be suitable for single as well as parallel efficient operation at any point in between the maximum and minimum system resistances.

(b)

(c) Pumps shall run smoothly without undue noise & vibration. Noise level shall be limited to 85 dBA at 1.86 M at sites. Vibration shall be limited to class II C of BS 4675 Part1.

(d)

(e) The pump set shall be suitable for starting with discharge valve open or closed.

(f)

(g) The pump set shall be capable of withstanding accidental rotation in reverse direction.

(h) Features of Construction

(i)

(j) Pump shall be centrifugal, back pullout, single stage type.

(k)

(l) Pump casing shall be of robust construction. Liquid passages shall be finished smooth and designed so as to allow free passage of solids. The volute tongue shall be straight across and filed to a smooth rounded edge. Casing shall be provided with wearing ring.

(m)

(a) Hand hole shall be provided in the casing to allow easy access to the impeller as well as to the casing throat. Casing drain connection with stainless steel collared plug shall be provided.

(b) Impeller shall be non clog, enclosed type with smooth blunt edges and large water ways so as to allow free passage of the 50 mm size solids. It shall be free from sharp corners and projections likely to catch and hold rags and stringy material.

(c) The critical speed of the rotor shall be at least 30% above the operating speed. Complete rotor shall be balanced dynamically.

(d) Replaceable shaft sleeves shall be provided and shall be securely locked or keyed to the shaft to prevent loosening. The surface hardness of the shaft sleeve shall be minimum 350 BHN.

(e)

(f) Bearings shall be easily accessible for inspection and maintenance. The bearings shall have a minimum working life of 40000 hours of working. Bearings shall be grease lubricated or non grease type.

(g)

(h) Stuffing boxes shall be of such design that they can be repacked without removing any part other than gland and lantern ring. Stuffing box drain with pipe connection shall be provided at the lowest point so that no leakage accumulates in it.

(i)

(j) Lantern ring shall be sandwiched between packings and shall be easily removable. Lantern ring shall be of axially split type. Grease shall be used for stuffing box sealing. Water will not be available for this purpose.

(k)

(l) The pump and motor shall be coupled through a flexible coupling. The motor shall be mounted directly on pump casing.

(m)

(n) It should be possible to lift the complete pump vertically through the opening provided in the motor floor level in the pumping station.

(o)

(p) Tappings shall be provided at suction and discharge nozzles for pressure gauge connection. Water flushing arrangement shall be provided for cleaning of sludge pipe line at its delivery side.

(q)

(r) Impeller wear ring hardness shall be 50 BHN higher than that of Casing wear ring.

(s)

(t) The material of construction for Centrifugal Dry Pit Pump shall be as follows :

(u)

(v)

Sr. No.	Component	Material	
		Non-clog type	For clean water
(i)	Impeller *	Stainless Steel : ASTM A 743 CF8M	Cast Iron to BS EN : 1561 Gr EN GJL 200 with 1.5 to 2% Nickel, or better
(ii)	Casing *	Cast Iron to BS EN : 1561 Gr EN GJL 200 with 1.5	Cast Iron to BS EN : 1561 Gr EN GJL 200 with 1.5 to 2% Nickel

Sr. No.	Component	Material	
		Non-clog type	For clean water
		to 2% Nickel	
(iii)	Shaft*	Stainless Steel : BS:970 Gr 431 S29	Carbon steel or better
(iv)	Shaft sleeve	Stainless Steel : ASTM A 743 CA 15 Hardness 400 BHN	Stainless Steel : ASTM A 743 CA 15 Hardness 400 BHN
(v)	Casing ring	Stainless Steel : ASTM A 743 CA 15	Stainless Steel : ASTM A 743 CA 15
(Vi)	Impeller ring	Stainless Steel : ASTM A 743 CA 15	Stainless Steel : ASTM A 743 CA 15

* Material test certificates shall be furnished by the Contractor

3.2 Dry Pit Pumps

3.2.1 General

The total head capacity curve shall be continuously rising towards shut off with the highest at shut off.

(n) Pumps shall be suitable for single as well as parallel efficient operation at any point in between the maximum and minimum system resistances.

(o) Pumps shall run smoothly without undue noise & vibration. Noise level shall be limited to 85 dBA at 1.86 M at sites. Vibration shall be limited to class II C of BS 4675 Part1.

(p) The pump set shall be suitable for starting with discharge valve open or closed.

(q) The pump set shall be capable of withstanding accidental rotation in reverse direction.

3.2.2 Features of Construction

(w) Pump shall be centrifugal, back pullout, single stage type.

(x) Pump casing shall be of robust construction. Liquid passages shall be finished smooth and designed so as to allow free passage of solids. The volute tongue shall be straight across and filed to a smooth rounded edge. Casing shall be provided with wearing ring.

(y) Hand hole shall be provided in the casing to allow easy access to the impeller as well as to the casing throat. Casing drain connection with stainless steel collared plug shall be provided.

(z) Impeller shall be non clog, enclosed type with smooth blunt edges and large water ways so as to allow free passage of the 50 mm size solids. It shall be free from sharp corners and projections likely to catch and hold rags and stringy material.

(aa) The critical speed of the rotor shall be at least 30% above the operating speed. Complete rotor shall be balanced dynamically.

(bb) Replaceable shaft sleeves shall be provided and shall be securely locked or keyed to the shaft to prevent loosening. The surface hardness of the shaft sleeve shall be minimum 350 BHN.

(cc) Bearings shall be easily accessible for inspection and maintenance. The bearings shall have a minimum working life of 40000 hours of working. Bearings shall be grease lubricated or non grease type.

(dd) Stuffing boxes shall be of such design that they can be repacked without removing any part other than gland and lantern ring. Stuffing box drain with pipe connection shall be provided at the lowest point so that no leakage accumulates in it.

(ee) Lantern ring shall be sandwiched between packings and shall be easily removable. Lantern ring shall be of axially split type. Grease shall be used for stuffing box sealing. Water will not be available for this purpose.

(ff) The pump and motor shall be coupled through a flexible coupling. The motor shall be mounted directly on pump casing.

(gg) It should be possible to lift the complete pump vertically through the opening provided in the motor floor level in the pumping station.

(hh) Tappings shall be provided at suction and discharge nozzles for pressure gauge connection. Water flushing arrangement shall be provided for cleaning of sludge pipe line at its delivery side.

(ii) Impeller wear ring hardness shall be 50 BHN higher than that of Casing wear ring.

(jj) The material of construction for Centrifugal Dry Pit Pump shall be as follows :

Sr. No.	Component	Material	
		Non-clog type	For clean water
(i)	Impeller *	Stainless Steel : ASTM A 743 CF8M	Cast Iron to BS EN : 1561 Gr EN-GJL-200 with 1.5 to 2% Nickel, or better
(ii)	Casing *	Cast Iron to BS EN : 1561 Gr EN-GJL-200 with 1.5 to 2% Nickel	Cast Iron to BS EN : 1561 Gr EN-GJL-200 with 1.5 to 2% Nickel
(iii)	Shaft*	Stainless Steel : BS:970 Gr 431 S29	Carbon steel or better
(iv)	Shaft sleeve	Stainless Steel : ASTM A 743 CA 15 Hardness 400 BHN	Stainless Steel : ASTM A 743 CA 15 Hardness 400 BHN
(v)	Casing ring	Stainless Steel: ASTM A 743 CA 15	Stainless Steel : ASTM A 743 CA 15
vi)	Impeller ring	Stainless Steel : ASTM A 743 CA 15	Stainless Steel : ASTM A 743 CA 15

* Material test certificates shall be furnished by the Contractor

3.3 Submersible Pumps

3.3.1 General

Pumps and drives shall be rated for continuous duty and shall be capable of pumping the flow range specified in the specifications without surging,

cavitations or excessive vibration to the limits specified. The pump shall meet maximum allowable shut off head. The pumps shall not overload the motors at any point on the maximum pump speed performance characteristic curve and the pump operating range within the limits of stable pump operation..The total head capacity curve shall be continuously rising towards the shut off as flow decreases throughout the entire curve from run out to shut off head with the highest at shut off.

Its total head capacity curve shall be continuously rising towards shut off with the highest at shut off, and its capacity shall be meet to handling sludge volume.

(a) Pumps shall be suitable for single as well as parallel efficient operation at any point in between the maximum and minimum system resistances.

(b) Pumps shall be suitable for VFD.

(c) The pumps shall be designed to handle solid sizes of up to 100 mm for the raw sewage application and 50 mm for all other process fluids. Specific gravity of sewage is 1.02.

(d) Pumps shall run smooth without undue noise and vibration, cavitations, oil or water leaks over the range of operation. To ensure vibration free operation, all rotative components of pump shall be statically and dynamically balanced to BS 6861.

(e) Vibration levels shall not exceed the levels given in BS 4675.

(f) The pump set shall be suitable for starting with discharge valve open and/or closed.

(g) The pump set shall be capable of withstanding the accidental rotation in reverse direction.

(h) Mixed Liquor Internal recycle pump shall be of tube installed.

3.3.2 Features of Construction

(a) Pump shall be centrifugal, vertical spindle, non-clog, wear resisting, and single stage type.

(b) Pump casing shall be of robust construction. Liquid passages shall be finished smooth and designed as to allow free passage of solids. The volute tongue shall be filed to a smooth rounded edge.

(c) Double Mechanical seals (back to back) shall be provided to protect the motor from ingress of sewage along the shaft. The preliminary and secondary seals shall be oil-lubricated with tungsten carbide or silicon-carbide faces and they shall be equipped with an electrical monitoring system for seal failure detection. . Seals must be capable of withstanding rotation in either direction. A detector shall indicate when moisture is leaking past the first seal.

(d) Impeller shall be non-clog enclosed type with smooth blunt edges and large water ways so as to allow free passage of the large size solids. It shall be free from sharp corners and projections likely to catch and hold rags and stringy materials.

(e) The critical speed of the rotor shall be at least 30% above the operating speed.

(f) Pump-sets shall have double bearings. Bearings shall be of the anti-friction type. Bearings shall be capable of taking the static weight of the rotating parts and any thrust generated by the operation of the pump. The bearing life shall be minimum 40,000 hrs of operation.

(g) Each pump shall be complete with a cast iron delivery connection arrangement for fixing to the concrete floor of the suction well. The joint between the pump discharge flange and the delivery piping shall be made by merely lowering the pump into guide rails / rope from access level. It shall be provided with all necessary fixings for guiding the pumps during lifting/lowering. Each pump shall be provided with a SS 316 lifting chain conforming to BS 1663 and BS 4942.

(h) Each pump shall be provided with an automatic coupling device for attaching the crane hook to the pump at low level, even whilst the pump is submerged, without the need for personnel to enter the well. This automatic coupling device shall easily and automatically couple and uncouple the hoist hook and be complete with necessary accessories. All links and cables shall be multi-stranded stainless steel.

(i) The materials of construction for submersible pumps shall be as follows :

S. No.	Component	Material
(i)	Impeller *	Stainless Steel : ASTM A 743 CF8M
(ii)	Casing *	Cast Iron to IS:210 Gr FG 200 with 1.5 to 2% Nickel.
(iii)	Mechanical seal (Motorside and Pump side)*	oOil-lubricated with tungsten carbide or silicon-carbide faces
(iv)	Shaft*	Stainless Steel : BS:970 Gr 316
(v)	Bush	Bronze IS 318 Gr. LT B2
(vi)	Guide rail pipe	Stainless Steel : BS:970 Gr 304
(vii)	Lifting Chain	Stainless Steel : AISI 316
(viii)	Fasteners and Foundation Bolts	Stainless Steel : BS:970 Gr 316

* Material test certificates from approved metallurgical laboratory shall be furnished by the Contractor

(j) Each pump shall be tested at the manufacturers premises for the full operating range of the pump to BS 5316 Part 1 .Pump performance shall be within the tolerance limits specified in the above said BS.

6.2 Chemical Feeding Equipment

6.3

6.4

6.5

6.6

6.7

6.8

6.9 Chemical Dosing Pumps

6.10

6.11 Chemical dosing pumps shall be piston, piston diaphragm or mechanical diaphragm type as specified. Pumps may be simplex or duplex arrangements to suit the capacity or process requirements. The pump design shall incorporate positive stroke return. The maximum stroking speed shall not exceed 100 strokes per minute (spm). Pump, motor and driving arrangement shall be mounted on a robust combined baseplate.

6.12

6.13 Pump liquid ends shall be selected for compatibility with the pumped liquid. Suction and discharge valves shall be the single ball type allowing a free flow self cleaning action. Ball and seat materials shall be resistant to abrasion.

(a) Pumps shall incorporate a variable stroke mechanism to allow the output to be varied while the pump is running. Stroke adjustment shall be manual or where specified by electrical or pneumatically controlled stroke positioner. A stroke length indicator and digital stroke counter shall be fitted. Pumps shall be driven by a flange mounted IP 55 motor, via an oil bath reduction gearbox and variable stroke mechanism giving stepless adjustment between zero and maximum stroke length. Where flow proportional dosing is required the variation of output shall be achieved by varying the speed of the pump motor and not the pump stroke length.

(b) The normal operating range of dosing pump shall be not less than 6:1.

a. Mechanical Diaphragm — Diaphragm rigidly coupled to the drive train. Single suction Pumps and discharge valves. Glandless. Accuracy: ± 3% of stoke.

b. Piston Pumps — Cylinder and piston with packed gland. Double suction and discharge valves can be fitted for greater accuracy at high pressure. Accuracy: ± 1% of stroke.

c. Piston Diaphragm Pumps — Diaphragm hydraulically operated by liquid displaced by a plunger and protected from excess pressure via a relief valve. Accuracy: ± 2% of stroke.

d.

e. Materials shall be selected to suit the chemicals being pumped. Liquid ends shall be polypropylene, 316 stainless steel, glass, or Hastelloy C. Diaphragm materials shall be butyl rubber, PTFE, or Hypalon and glands shall be PTFE or Neoprene.

f.

g. Each pump shall be provided with inlet and outlet isolating valves and where necessary, with pressure relief and non-return valves. Dosing pumps shall be provided with back pressure loading valves and pulsation dampeners in the delivery lines depending on the downstream conditions.

h.

i. A relief valve shall be incorporated in the delivery lines under conditions where the pump discharge pipe can be shut off or where pressure may rise to an excessive point. The relief valve shall be sized to handle the system pressure and to discharge maximum pump output freely, and shall be located in the discharge line between the pump and the first downstream isolating valve or in the case of dosing pumps the back pressure loading valve. Relief valves when used on pumps handling non-hazardous chemicals shall discharge the vented liquid to waste. When used on hazardous chemicals the valve outlet shall be piped back to the suction supply tank or bunded area. The open end of the return pipe shall be located where it is visible, so that any relief valve leakage/operation can be detected. Pump transferring/dosing chemicals to systems under pressure shall incorporate a pressure gauge on the pump delivery. Air cocks shall be provided for release of air where necessary.

j.

k. Unless otherwise specified flushing connections shall be provided at each pump inlet and flushing shall be manual. When flushing, water shall be discharged either

locally through a drain valve or to the point of application of the chemical. Facilities shall also be provided for flushing chemical pump suction and delivery manifolds and delivery lines to point of application.

l.

m. Dosing pumps and motors shall preferably incorporate an integral reduction gearbox drive which shall be totally enclosed and oil bath lubricated. The gear box shall incorporate the cams for the diaphragm drive and shall be provided with filling and drain connections and visible oil level indication.

n.

o. All dosing pumps shall have facility/terminals for pulse input & output (4-20 Ma) to facilitate online control via plant PLC & SCADA.

p.

q. Chemical Tank and Mixer

(i) General

This tank shall be used to dissolve the alum or polymer to a constant concentration and feed the solution to the outlet channel of the aeration tank or the dewatering equipment. It shall be a vertical tank and shall be composed of tank main body, mixer, manhole, electrical level gauges, direct reading level gage, ladder, air exhaust pipe etc.

(ii) Fabrication

(a) The tank shall be made of corrosion resistant material.
(b)
(c) The tank shall be provided with a removable cover to prevent chemical scattering, and also with a vent pipe.
(d)
(e) The tank shall be provided with necessary mounting seats for overflow pipe, etc.
(f)
(g) The motor-driven mixer shall be vertical speed reducer, direct-coupled type of 2-stage propeller type, as a rule and shall be constructed to endure continuous operation free from vibration, etc. The mixer shall be at the center or at a position off the center according as the tank being angular or circular.
(h)
(i) The mixer shall be protected by electrical prevention of dry operation.
(j)
(k) The tank shall be constructed to seal gas and splash from below at the area where the mixer shaft drive portion passes through.
(l)
(m) Alum feed cage of stainless steel shall be provided inside the alum solution tank.
(n)

(o) Materials
(p)
(q) (a) Main Tank body : GRP or equivalent
(r) (b) Mixer frame : Stainless steel
(s) (c) Mixer shaft : Stainless steel
(t) (d) Blade : Stainless steel
(u)
(v) Accessories (per Unit)
(w)
(x) (a) Foundation bolt and nut x 1 set
(y) (b) Air vent pipe x 1 set
(z) (c) Mixer x 1 unit
(aa) (d) Direct reading level gauge x 1 unit
(bb)
(cc)
(dd) Alum Dispersion Rapid Mixer
(ee)
(ff) (a) The alum dispersion rapid mixer shall be in-channel submersible chemical vacuum induction unit and consist of chemical induction unit with mount bracket, guide rail assembly, floor mount base, boom hoist with manual brake winch and 316 SS cable, hose assembly, control panel and submersible power cable.
(gg)
(hh) (b) The unit shall be provided instantaneous diffusion / mixing and the highest level of durability and performance required for chemical feed application.
(ii)
(jj) The hermetically sealed 316 SS motor shall provide the highest level of durability and performance required for chemical feed applications. All wetted materials shall be constructed from Grade 2 Titanium (unalloyed) and shall be designed for use with all common water and wastewater treatment chemicals. The mounting bracket shall be engineered for installing in open-channel applications.
(kk) The material of construction of chemical induction shall be as follows:
(ll)

S. No.	Component	Material
(i)	Vacuum chamber	Titanium
(ii)	Vacuum port	Titanium
(iii)	Vacuum enhancer	Non-metallic
(iv)	Propeller	Titanium
(v)	Propeller bolt	Titanium
(vi)	Shaft	Titanium
	Mechanical seals	Carbon /ceramic
(vii)	Hardware	316 Stainless steel

3.4 Induction Motor (Dry pit Sewage / Sludge Pumps)

3.4.1 Design Requirements

The motors shall be suitable for operating on a 415 V, 50 Hz, 3 phase, Ac supply.

The motors shall generally conform to IS: 325 or relevant equivalent internationally approved standards. Additionally the specific requirements mentioned in the following clauses shall also be met.

3.4.2 Performance and Characteristics

(a) Motors shall be capable of giving rated output without reduction in the expected life span when operated continuously under the following supply conditions:

(i) Variation in supply voltage ± 10%
(ii) Variation in supply frequency ± 5%
(iii) Combined voltage and frequency variation ±10%

(b) Motors shall be suitable for full voltage direct-on-line starting or star delta starting. Minimum permissible starting voltage shall be 85% of the rated voltage.

(c) The Power rating of the motor shall be the larger of the following :

(i) 115% of the power input to the pump at duty point at a speed corresponding to the frequency of 48.5 Hz.
(ii) Maximum power input while operating single pump corresponding to the speed of 50 Hz.

3.4.3 Insulations

Any joints in the motor insulation such as at coil connections or between slot and winding sections, shall have strength equivalent to that of slot sections of the coil. The insulation shall be given tropical and fungicidal treatment for successful operation of the motor in hot, humid and tropical climate. The motors shall be provided with class F insulation with temperature rise limited to that of class F insulation. The degree of enclosure protection of motors shall be of minimum IP 55.
Motors shall be given power house treatment. This comprises an additional treatment to the winding over and above the normal specified treatment. After the coils are placed in slots and all connections have been made, the

entire motor assembly shall be impregnated by completely submerging in suitable insulating compound or varnish followed by proper baking. At least three such submersions and backings shall be applied to the assembly.

3.4.4 Constructional Features

The motor construction shall be suitable for easy disassembly and reassembly. The enclosure shall be sturdy and shall permit easy removal of any part of the motor for inspection and repair.

a) Motors weighing more than 25 kg shall be provided with eyebolts, lugs or other means to facilitate safe lifting.
b) The rotor bars shall not be insulated in the slot portion between the iron core laminations for squirrel cage motors.

3.4.5 Terminal Box

Terminal boxes shall be of weather proof construction designed for outdoor service. To eliminate entry to dust and water, gaskets of neoprene or approved equivalent shall be provided at cover joints and between box and motor frame. It shall be suitable for bottom entry of cables. It shall be capable of being turned through 360 degrees in steps of 90 degrees.

a) The terminals shall be of the stud type with necessary plain washers, spring washers and check-nuts. They shall be designed for the current carrying capacity and shall ensure ample phase to phase and phase to ground clearances. Suitable cable glands and cable lugs shall be supplied to match specified cables.

Separate terminal boxes shall be provided for the following:
(i) Starter leads; and
(ii) Space heater

3.4.6 Accessories

Two independent earthing points shall be provided on opposite sides of the motor, for bolted connections. These earthing points shall be in addition to earthing stud provided in the terminal box.

3.4.7 Heating during Idle Period

For motors rated below 30 kW, during idle periods, the stator winding will be connected to required single phase, 50 Hz, AC supply for heating and

elimination of moisture. The supply will be connected between any two terminals.

Motors rated 30kW and above shall have space heaters suitable for 230V, single phase, 50 Hz, AC supply. Space heaters shall have adequate capacity to maintain motor internal temperature above dew point to prevent moisture condensation during idle period. The space heaters shall be placed in easily accessible positions in the lowest part of the motor frame.

3.4.8 Earthing Pad

Two independent earthing pads of non-corrodible metal shall be welded or brazed at two locations on opposite sides complete with suitable bolt and washers for earthing. These earthing pads shall be in addition to earthing stud provided in the terminal box.

3.4.9 Rating Plate

The following details, in addition to those specified in applicable standards shall be included on the rating plate.

Rated voltage, kW rating, frequency, efficiency, power factor, temperature rise of windings in degree centigrade at rated load, and ambient conditions.

Type of bearings, recommended lubricant, lubricating interval & re-lubricating quantity.

3.4.10 –Tests

Motor shall be subjected to all the type test (one from similar rating of each lot) and routine tests as per applicable standard in the presence of the Engineer. Copies of test certificates for all brought out items shall be furnished at the time of inspection for the Employer's approval. The Contractor shall ensure to use calibrated test equipment / instruments having valid calibration test certificates from standard laboratories traceable to National / International standards.

3.4.11 Low Voltage Motors

Motors shall be suitable of starting and accelerating the load with the applicable method of starting, without exceeding acceptable winding temperatures, when the supply voltage is 85% of the rated motor voltage.

The locked rotor current of the motor shall not exceed 600% of full load current (subject to tolerance as per the applicable standard).

Motors shall be designed to withstand 120% of rated speed for two minutes without any mechanical damage, in either direction of rotation.

Stator leads shall be brought to the terminal box as insulated cable through a suitable barrier and terminated in clamp type terminals.

Motors rated 30 kW and above shall be provided with space heaters with adequate capacity to maintain motor temperature to prevent moisture condensation on the insulation during idle condition. The space heaters shall be suitable for 240V single phase 50 Hz supply. The degree of enclosure protection of motors shall be of minimum IP 55.

3. —Induction Motor (Submersible Pump)

3.5.1 Performance and Characteristics

a) The submersible motor shall conform to IS: 9283:1979 and the submersible cable shall conform to clause no. 4.4 of the IS: 9283:1979. The motors shall be suitable for operating on a 415 V, 50 Hz, 3 phase, Ac supply. Pump motor shall be of the squirrel cage submersible type, protected to IP 68.Motor for submersible pump shall be capable of start up and operation in the event of a completely flooded wet well. Motor cooling for submersible pump must be achieved by a cooling jacket, using the pumped media to cool the motor. The pump impeller must be equipped with a system to ensure a pumped flow of liquid through the cooling jacket and also incorporate a device to prevent the liquid channels from blocking with hair and foreign material. This motor shall be capable of starting 10 times per hour. The insulation class of motor winding shall conform to class F .Additionally the specific requirements mentioned in the following clauses shall also be met.

b) Motors shall be capable of giving rated output without reduction in the expected life span when operated continuously under the following supply conditions :

(i) Variation of supply voltage from rated motor voltage ±10%
(ii) Variation of supply frequency from rated frequency ±5%

(iii) Combined voltage and frequency variation ±10%

The starting current of motor shall not exceed 200% of rated full load current for star/delta starting and 600% of rated full load current for DOL starting, under any circumstances.

Motors shall be suitable for full voltage direct-on-line starting or star-delta starting.

Motors shall be capable of starting and accelerating the load with the applicable method of starting, without exceeding acceptable winding temperatures, when the supply voltage is in the range 85% of the rated motor voltage to maximum permissible voltage.

The locked rotor current of the motor shall not exceed 600% of full load current (subject to tolerance as per the applicable standard) unless otherwise specified.

Motors shall be designed to withstand 120% of rated speed for two minutes without any mechanical damage, in either direction of rotation. The motor vibrations shall be within the limits specified in applicable standard unless otherwise specified for the driven equipment.

Except as mentioned herein, the guaranteed performances of the motor shall be met with tolerances specified in applicable standard, IS: 9283-1979.

Motor insulation shall conform to Class F and the maximum temperature rise shall not exceed 95deg C , when measured by winding resistance method and 85 deg C , when measured by thermometer method for an ambient temperature of 45 deg C. The motor windings shall be protected with a waterproof material and shall incorporate a thermal sensor in each phase to safe guard against high winding temperatures. The thermal sensor shall be connected into the control circuit of the starter and signals taken for continuous monitoring of winding temperatures. The motor shall incorporate a cut out device to detect the presence of any liquid in the motor enclosure, in the form of non resetting moisture switch. The terminal connections for the power and protective circuits shall be housed in a completely sealed and water proof junction box, complete with all external corrosion resistant cable glands. The pump units shall be provided with power and protection circuit cables of sufficient length to reach from the motor junction box to the local isolator located at the panel floor level.

Protection against increase in stator winding temperature (150°C) bearing temperature, leakage in stator housing and terminal box shall be provided. Minimum three number thermistors in series are to be provided to sense the stator winding temperature. Sensors are to be provided to detect if leakage of sewage into the oil housing is above 30 % concentration.

Bimetallic thermal switch to trip the motor against increase in temperature shall be provided.

The power rating of the motor shall be larger of the following:

(i) 115% of the power input to the pump at duty point at a speed corresponding to the frequency of 48.5 Hz.
(ii) Maximum Power input while operating single pump corresponding to the speed of 50 Hz.

Motor shall be offered for routine and type tests in accordance with IS: 4029 and IS: 325 at the manufacturer's works.

3.5.2 Submersible Cable

(a) The submersible cable shall conform to clause no. 4.4 of the IS: 9283:1979.The power cable shall be PVC insulated and PVC sheathed, flexible, 3.5 core flat type. The size of the conductor shall be adequate for continuous use under water and air. The half core shall be used for earthing.

(b) The control cable shall be PVC insulated PVC sheathed, flexible, flat type and shall be adequate for continuous use under water and air. The control cable for stator winding temperature sensor (Thermistors) 3 core x 2.5 sq. mm copper conductor and for bimetallic thermal switch 2 core x 2.5 sq. mm copper conductor shall be provided.

(c) In case a joint is required to be made between the lead cable supplied with the motor and the user's cable connectors, a detailed procedure of cable jointing to make a watertight joint shall be provided by the manufacturer.

(d) The size of the conductor and length of cable should be suitably selected so that the voltage drop at motor terminals does not exceed 3 percent of the rated voltage.

3.5.3 Earthing

Earthing of the motor shall be done in accordance with the relevant provisions of IS: 3043:1966. For the purpose of earthing these motors, earthing connection may be made to discharge pipe.

3.5.4 Insulation

(a) Any joints in the motor insulation such as at coil connections or between slot and end winding sections, shall have strength equivalent to that of the slot sections of the coil.

(b) The insulation shall be given tropical and fungicidal treatment for successful operation of the motor in hot, humid and tropical climate. The tropicalising treatment shall be as per the applicable standard.

(c) The stator winding shall be made from high conductivity annealed copper conductor, PVC insulated winding wires conforming to IS: 8783:1978 for wet type motors. The stator winding shall be of high conductivity annealed copper enameled insulated wires conforming to IS: 4800 (Part-VII):1970 for dry type motors.

3.5.5 Temperature Rise

The temperature-rise test of the motor shall be taken with the motor coupled to the suitable pump to give the full load output of the motor. When the various temperatures are stabilized, the set is stopped and the temperature-rise of the stator winding by the resistance method shall not exceed 35°C. During the test, the temperature of the cooling water may not exceed 35°C. As the cable resistance will also be substantial, it is necessary that while calculating the temperature rise by resistance method, due care is taken to account for the correct hot and cold resistance of windings.

3.5.6 Constructional Features

The motor shall be suitable for continuous use in fully or partially submerged condition. A built in cooling system must allow the motor to operate continuously at its rated output regardless of whether the electric motor is submerged or not, by providing either external or internal cooling arrangement.

3.5.7 Terminal Box

Terminal box shall be of weather proof construction to eliminate entry of water and dust.

The terminals shall be of the stud type with necessary plain washers, spring washers and check nuts. They shall be substantially designed for the current carrying capacity and shall ensure ample phase to phase and phase to ground clearance.

3..

Gate –controlled Weir

These Gates are downward opening type and shall be used for flow splitting, Decanting of reservoir or a tank OR For maintaining precise level control in a reservoir or a tank.

The gates shall have minimum following features:

a. Suitable for seating and unseating Head
b. Flange /Flat back frame design
c. Metal to Metal sealing on 3 sides
d. Manual lift mechanism to enable single person operation with effort not to exceed 20 Kgs.

The material of construction of Gate –controlled Weir shall be complied with " 8.83.7 Sluice Gate".

3.7 – Sluice Gate

(a) Design Requirements and Construction Features

The construction of sluice gates shall be in accordance with the specification and generally as per IS: 13349. All sluice gates shall be of the rising spindle type.

(b) Frame

The frame shall be of the flange back type and shall be machined on the rear face to bolt directly to the machined face of the wall thimble.

(c) Seating Faces

Seating faces shall be made of full width, solid section; dove-tail strips of stainless steel. They shall be secured firmly by means of counter sunk fixings in finished dove-tail grooves in the frame and slide faces in such a way as to ensure that they will remain permanently in place, free from distortion and loosening during the life of the sluice gates.

(d) Wedging Devices

Sluice gates shall be equipped with adjustable side, top and bottom wedging devices as required providing contact between the slide and frame facing when the gate is in closed position.

(e) Lifting Mechanism

(i) Sluice gate shall be operated through suitable lifting mechanism which shall incorporate suitable gearing if required, to keep the torque requirement within 7 kg.m.

(ii) Lifting mechanism shall incorporate a strong locking device suitable for use with a padlock or padlock and chain.

(iii) Lift mechanism shall be provided with a suitable position indicator to show the position of the gate at all times.

(f) Wall Thimbles

The cross section of the thimble shall have the shape of the letter 'F'.

(g) Lifting Lugs

Lifting lugs shall be provided for all gates.

(h) Flush Bottom Seal

(i) When sluice gates are provided with flush bottom seals, the wedging device and facing along the bottom edge of the slide and frame shall be omitted.

(ii) A solid square cornered, resilient rubber seal shall be provided on the bottom facing of slide. The seal shall be securely fastened to the bottom face of the slide by a retainer bar and corrosion resistant metal fasteners. The top surface of the bottom facing of frame shall be flush with invert of the gate opening. Bottom facing of the slide shall be accurately machined to make contact with the seal when the slide is closed.

Suitable arrangement shall be made for on all the sluice gates or actuators such that the portable electric actuator is capable of operating all sizes of sluice gates.

1 No. of Portable type of electric actuator for closing and opening of sluice gates shall be provided at each STP, so that the closing and opening operation time shall be maximum of 10 minutes

(i) Suitable arrangement shall be made on all the sluice gates or actuators such that the actuator is capable of operating all sizes of sluice gate, under this contract.

(j) The material of construction of sluice Gate shall be as follows:

S. No.	Component	Material
(viii)	Wall Thimble	Cast Iron : IS 210 Gr. FG 200
(ix)	Frame and Slide	Cast Iron : IS 210 Gr. FG 200
(x)	Seating faces	Stainless Steel : ASTM Countersunk fixing A276 type 316
(xi)	Wedge	Stainless Steel : ASTM A743 CF8M or SS316
(xii)	Stem	Stainless Steel: ASTM extension A276 type 316
(xiii)	Stem nut	Stainless Steel : ASTM A743 CF8M
(xiv)	Stem Coupling	Stainless Steel : ASTM A276 type 316
(xv)	Fasteners, anchor	Stainless Steel : ASTM bolts and nuts A276 type 316
(xvi)	Lifting mechanism, Pedestal gear	Cast Iron : IS 210 Grade FG 200

S. No.	Component	Material
	house cover and stem guide	
(xvii)	Lift nut	Bronze : ASTM B 148 (CA952, CA954 or CA958)

3.8 Heavy Duty ——Mechanical Coarse Bar Screen

3.8.1 -General

(a) The screen shall be installed in raw sewage inlet channel, and the screen shall be of the front raking type.

(b) The screen shall be capable of performing the duties set out in this Specification. All the materials and sub-assemblies used shall be suitable for outdoor application. They shall be constructed so that maintenance is kept to a minimum.

(c) **There shall not be any moving part, sprocket, bearings, etc. continuously immersed in sewage.** All lubricating points shall be conveniently accessible from the deck level.

(d) The screen shall be suitable for discharging 75% of the screened material lifted from the screen into the chute.

(e) The screen shall be designed such that in case of heavy accumulation of solids the same is to be removed gradually without overloading or damaging the screen bars or mechanism.

3.8.2 —Frame work

The frame work of the screen shall be of robust construction with intermediate cross bracing. The lower ends and sides of the frame shall be grouted in concrete. Each screen shall have an independent canopy at the top for weather protection.

3.8.3 —Screen bar assembly

Screen bar assembly shall be fitted across the screen chamber. Screen shall have a series of vertically oriented bars spanning the inlet channel and spaced

as specified. Bars shall be sufficiently rigid to prevent vibrations in stream wise and lateral modes and to withstand the maximum differential head that will occur with the screen totally blinded. Bars shall have tapered cross section to prevent jamming of screenings between bars. Bars shall have supports only at both ends.

3.8.4 Rake carriage

(a) The rake carriage shall comprise a stiffened frame work to which is attached replaceable rake tines. The rake tines shall be suitable to accommodate bulky screenings. Rake carriage shall incorporate suitable devices to enable the rake to ride over any small obstacles wedged in the screen and automatically stop the drive motor in the event of the rake jamming against a large obstruction. There shall not be any mechanical damage resulting from obstruction wedged in the screen bars. The rake carriage shall always come to rest in a parked position with the rake above the sewage level.

(b) The screen shall be cleaned automatically through an adjustable timer. The rake lowered will clear screen bars at the beginning of a cycle and accurately engage with the screen bars at the bottom of the channel. The tine profile and rake motion shall be designed to elevate screenings to the discharge chute at deck level without debris falling back or being forced through the screen. The rake shall be suitable for levating debris encountered at any level. Rake tines shall be replaceable.

(c) The screenings shall be discharged from the unit by a wiper mechanism down to a discharge chute leading to a conveyor belt. Arrangement shall be such as to ensure that screenings are discharged to the discharge chute leading to the conveyor. The rake tines shall then be retracted and the unit ready for the next cycle.

3.8.5 Rake Lifting Mechanism

Lifting mechanism shall consist of a SS 316 wire rope or chain and ~~C.I.~~ SS sprocket.

3.8.6 Inspection Platforms

An inspection platform shall be provided for periodic checking and maintenance of the drive and other critical parts. A ladder with handrails for access to this

platform shall be fixed. Suitable hand rails shall be provided for safety on the inspection platform and also at deck level.

3.8.7 –Dead plate

Mild steel dead plate extending from the top of the bars to the deck level shall be provided to ensure that screenings do not fall back. Dead plate shall be made of minimum 5 mm thick plate. The clearance between the tines and the dead plate shall not exceed 5 mm.

–

3.8.8 Driving Mechanism

The driving mechanism shall consist of a sturdy reduction gear unit driven through multiple 'V' belts or directly by an electric motor. Motor shall be mounted in such a way that the tension of the 'V' belts can be adjusted. A manually reset torque limiter shall be provided between the motor and gear unit, incorporating a limit switch to cut off the supply to motors in the event of an overload.

3.8.9 –Gear Reducer

(a) The reducer shall be sized and selected with a minimum service factor of 2.0 times the motor nameplate horse power rating in accordance with applicable American Gear Manufacturer's Association Standards. The reducer shall have a life of 40,000 hours based on the motor name plate horse-power. The reducer shall have an efficiency of not less than 90% based on reducer input.

(b) All gear meshes shall be oil lubricated. All gears shall be provided with an oil reservoir for instant lubrication on starting. The gear reducer housing shall be provided with an oil level indicator and oil drain with necessary fittings.

(c) The gear reducer shall be of cast iron construction. The reducer housing shall also include suitable lifting lugs and external gear train inspection covers for each gear train. The gears shall be matched for maximum tolerance variation. The gear reducer shall be suitable to reduce the motor asynchronous speed to achieve the required speed of raking.

3.8.10 –Control System

(a) The screening operation shall be carried out through adjustable timers which are adjustable at site for 0-60 minutes for interval between two operations.

(b) Control system for the conveyor shall be designed to achieve the following:

(i) Conveyor shall be started when any of the rakes starts it's upwards travel.

(ii) Conveyor shall be stopped with a time delay (by adjustable timer) after rake is stopped.

(c) Weatherproof, lockable, emergency mushroom headed stop push buttons shall be provided near each motor for screen and conveyor belt, operation of stop push button, and overload prevention for screen and belt conveyor shall be included in the control scheme.

3.8.11 –Conveyor System

(a) For the disposal of screenings, a common motor driven endless belt conveyor shall be provided. The conveyor shall be designed in accordance with IS 11592 or equivalent. The conveyor and chutes shall be suitable for handling occasional heavy objects which will cause shock loads.

(b) The construction of the frame and support shall be robust and torque resistant. Belt conveyor shall be of –20 deg. trough type complete with drive assembly structures, idlers, pulleys and belt cleaners. Idlers and pulley shall be provided with anti-friction bearings.

(c) The belt material shall be two poly nylon or equivalent with minimum 3 mm neoprene covering on carrying side. Splicing shall be employed to make the belt endless. The belt shall operate over three roll twenty degree, troughing idlers. The idlers shall rotate on precision type, deep groove, single row ball bearing with built-in close fitting triple labyrinth grease seal. The ends of the outer shell shall be counter boredcounterbored and a full length centre tube journalled concentricity. The outer shell, centre tube and precision die formed steel ends shall be brazed into an integral unit to provide concentricity. The

ends of the centre tube shall be bored concentrically with each other after roll assembly to provide correct bearing alignment and to provide prestressing of boring. The centre tube shall be grease fit after assembly. Troughing idlers shall have means of adjustment or ensuring belt tracking. On the return run the belt shall operate over flat roll idlers having bearing, shaft and lubrication arrangements as above for carrying idlers. Spacing of idlers shall be of 1200 mm on carrying run and 2400 mm on return run.

(d) The head and tail pulleys shall be manufactured from welded steel/any alloy steel and shall be provided with rubber lagging. Lagging for drive pulleys shall have herringbone grooving. Pulleys shall be equipped with taper lock bushings. The tail pulley shall incorporate a screw rake for adjusting belt tension. Head and tail pulleys shall be adequately guarded.

(e) Shafting for pulleys shall be of heat treated carbon steel. They shall be forged, ground and polished to obtain close diameter tolerances. The head shaft shall be provided with roller bearing pillow blocks.

(f) The belt conveyor shall be driven by a squirrel cage, TEFC motor. A V-belt drive arrangement shall be provided between the motor and a helical speed reducer, the latter shall be mounted on the end of the head shaft. The driving pulley shaft shall have back stops to prevent backward movement of the belt.

(g) The conveyor shall be supported on 150mm channel sections with 14 gauge steel deck plate between the two runs of the belt and the necessary supports to the floor. The floor supports shall be made out of steel plates having minimum 6 mm thickness. The conveyor shall be protected from weather by a 'dog box' type canopy.

(h) An adjustable belt scraper shall be provided on the hopper end of the conveyor belt. The scraper and attachments shall be of fibreglass/fibre reinforced plastic/PVC.

(i) Screenings discharge chutes shall be provided to transfer screenings from the screens to the troughed belt conveyor and from the conveyor discharge to skip. The latter chute shall extend beneath the belt scraper and shall allow access for maintenance of the belt scraper. Chutes shall be designed to minimize the accumulation of rags and stringy materials.

(j) The conveyor shall be fitted with an emergency stop operated by wire rope at foot level. Two Nos. belts way switches shall be provided on conveyor.

6.13.1 Portable Screenings Container

6.13.2

6.13.3 Portable screenings containers made of galvanized steel shall be provided to store the screenings until time of pick up. The container shall have capacity of approximate 2.0 cu.m and shall be of a convenient height to permit the discharge of screenings directly into the container without having to transfer the screenings manually. The containers shall have hinged covers and their design shall permit their being lifted by an overhead hoist or packer truck. The container will have four wheels each of about 20 cm diameter and two of which shall be swivel castors. The maximum height of container including wheels shall be 66 cms. The sides shall be constructed of 12 gauge steel. The bottom of container shall be made of 5 mm plate steel. The containers shall be reinforced with 50 mm x 50 mm x 5 mm angle.

6.13.4

6.13.5 3.8.12 –Motors

(a) Motors shall be squirrel cage type conforming to IS 325. The power rating of motor shall be at least 125% of maximum power requirement. The other features of motors shall be as follows :

(i) Type of duty : Intermittent (S4)
(ii) Method of Starting : DOL
(iii) Class of insulation : F (Temperature rise limited to class B)
(iii) Type of enclosure : TEFC
(iv) Degree of protection : IP 55

(b) The material of construction of Mechanical Raked Screen shall be as follows :

S. No.	Component	Material
(i)	Screen	Stainless steel SS316
(ii)	Frame (Side and Bottom Portion)	Stainless steel SS316
(iii)	Raked tines	Stainless steel SS316

(iv)	Fasteners including Anchor bolts	Stainless Steel : ASTM A 276- Type 316
(v)	Screen canopy	Stainless Steel: BS:970 Gr 304
(vi)	Chutes	Mild Steel - Galvanized

3.

Mechanical Medium Bar Screen

(a) The screen shall be installed in inlet channel to grit chamber, and the screen, shall consist of continuously moving perforated stainless steel panels.

(b) The aperture size of the screen shall be 6 mm.

3.9.1 Construction

(a) Frame :

The frame shall consist of two lateral stainless steel 316 plates connected by means of cross braces.

(b) Chain wheels :

The machine shall work on the endless chain principle and incorporate chain wheels at the top and bottom. The top wheels shall be keyed onto the main drive shaft. The bottom wheels shall be carried on stub shafts incorporating a sealed bearing of suitable synthetic material.

(c) Chain :

The chain shall be constructed in stainless steel with the screen panels directly attached.

(d) Screen Panels :

Minimum 3mm thick panels of stainless steel 316 construction shall incorporate 6mm diameter perforations. These panels shall be carried on the chains. The panels shall be specially formed to give a very rigid construction and shall create steps to enable larger screenings to be removed.

(e) Seals :

Polypropylene sealing brushes shall be incorporated at each side and across the bottom of the screen to prevent screenings from by-passing the screen panels.

(f) Screenings Discharge :

(i) Screenings shall be discharged on the downstream side of the unit and shall be removed from the screen panels by a heavy duty rotating brush. The brush material shall be polypropylene.

(ii) Screenings are delivered down an enclosed chute.

(iii) Two nos. screening collection containers (wheeled) of suitable capacity shall be supplied with the screens.

(g) Enclosure

The entire assembly shall be enclosed in reinforced fiber glass housing. A hinged front cover shall be provided to give access to the rotating brush assembly and screen discharge area. A sliding inspection hatch shall also be incorporated.

(h) Drive Unit

(i) The drive to the main shaft shall be TEFC weatherproof IP55 motor fitted with an anti-condensation heater. The motor shall be fangedflanged to a shaft mounted gear unit giving the final output speed. This shall produce a linear speed for the screen panels of about 3 m/min.

(ii) The drive shall be protected from mechanical overload by an electrical current sensing device in the screen control panel.

(i) Overload prevention switches shall be provided to annunciationannunciate screen jamming.

(j) Suitable conveyorconveyer arrangement shall be provided to transfer the screenings to the nearest container/trailer.

(k) A spray system shall be provided to backwash the screen panels and to help in cleaning the screenings. Water / treated sewage shall be used for back wash purpose.

6.14 Automatic Drum screen

6.15

6.16 i) General

6.17

6.18 The automatic drum screen shall be composed of screen, screw conveyor, washing unit, dewatering unit and drive unit, etc. The automatic drum screen shall have 6 mm opening and shall be used to block, scrape, wash, and dewater the suspended solid or scum in the influent or sludge.

6.19

6.20 (ii) Design Condition

6.21

6.22 (a) This equipment shall be designed with sufficient safety factor in strength.

6.23

6.24 (b) This equipment shall be of integrated type and shall be constructed such that it can be installed easily.

6.25

6.26 (c) The difference of water level, the characteristics of suspended solid, and flow rate shall be considered in design.

6.27

6.28 (iii) Fabrication

(a) Drive unit

- Cycloidal reduction gear or worm reduction gear shall be used as drive unit. Drive unit shall transmit the power by means of gear transmission or direct connection with coupling.

- Gear box shall be provided in case of gear transmission.

(b) Screen

- The screen shall be made of cylindrical stainless steel. The screen shall have a smooth finish in order to prevent the attachment of screenings and shall be arranged with equal spacing.

- An electrical pole shall be installed in front of the screen in order to detect the overflow and control operation.

(c) Rake

- The rake shall be connected with the screw conveyor along the same axis and shall rotate with it. The raked screenings shall be scraped down into the screw conveyor by the scraper.

- The rake shall be constructed such that the screenings never remain on the screen after raking.

(d) Screw conveyor

- The impeller and shaft of the screw shall be a welded structure of stainless steel and shall endure the incurred stress.

- A dewatering device shall be provided at the upper portion of the screw conveyor. The dewatering device shall be sealed and shall have sufficient strength to endure the pressure of screenings and scum. The inspection hole and washing water pipe shall be provided for the dewatering device. The inspection hole shall permit easy inspection and the washing water pipe shall be used to wash the casing for filtrated liquid.

(e) Shaft and bearing

- The shaft of screw shall be made of stainless steel and shall have sufficient strength to endure the incurred stress.

- The submerged bearing shall be an oil-less enclosed pneumatic type. For a bearing installed above the water level, an automatic oiling device shall be provided.

(f) Washing unit

Washing nozzles shall be provided at the inlet of the screw conveyor in order to wash down the screening or scum with pressurized water.

(g) Chute

A stainless steel chute shall be provided at the discharge part of the screw conveyor. The chute shall be constructed such that the screenings are blocked from being discharged.

(iv) Materials for automatic drum screen

(a) Screen : Stainless Steel AISI304

(b) Rake : Stainless Steel AISI304

(c) Screw conveyor : Stainless Steel AISI304

(d) Chute : Stainless Steel AISI304

(v) Protection Equipment

(a) Mechanical protection

For cyclodial reduction gear, a built in torque limiter shall be provided.

(b) Electrical protection

An over-current detector with instantaneous converter shall be provided in case the mechanical protection is not provided.

(vi) Accessories (per Unit)

Anchor bolts and nuts - 1 set

Manual Medium Bar Screen

The screen shall be installed in inlet bypass channel to grit chamber.

The aperture size of the screen shall be 10 mm and 50 angle of inclination.

The screen shall be fabricated out of galvanized M.S flats and fixing bolts shall be of stainless steel.

The rectangular trash screens shall comprise galvanized M.S flats, 10 mm thick and 50 mm wide in section.

The screen shall be rigidly fixed to the frame.

All the bypass screens shall be provided with 2 sets of SS 316 cleaning rakes.

Manually Operated Travelling Crane

6.28.1 Crane

(a) The crane shall be manually operated for both terminal sewage pumping station and return activated sludge pumping station.

(b)

(c) The capacity of crane shall be as per the equipment list in particular mechanical requirement and of class II.

(d)

(e) The crane bridge shall consist of a single bridge girder carrying two wheels at each end of the span. Steel used shall be tested quality steel conforming to IS 2062.

(f)

(g) The long travel bridge wheels shall be rim toughened; heat treated galvanized carbon steel or low alloy steel or C.I. They shall be double flanged type. The wheels shall have antifriction ball/roller bearings. The wheels shall be machined on their treads to match the runway rail section. The bridge shall have a geared shaft and pulley connecting to opposite wheels of the span, to achieve the long travel motion of the bridge, by means of a chain. The runway rails of adequate strength and rigidity, rail clamps and other accessories for mounting the rails and suitable end stops for the bridge shall be supplied by the Contractor.

(h)

(i) Trolley and Chain Pulley Block

(j)

(k) The chain pulley block shall be operated on the lower flange of the bridge girder.

(l)

(m) The load chain shall be made of alloy steel as per IS:3109. It shall be heat treated to give ductility and toughness so that it will stretch before breaking. It shall be of welded construction with a factor of safety not less than 5.

(n)

(o) The hand chains, SS 316, for the hoisting and traverse mechanism shall hang well clear of the hook and both the chains shall be on the same side. The hand chain wheel shall be made from pressed sheet steel and shall be provided with roller type guarding to prevent snagging and fouling of the chain.

(p)

(q) All the gearing shall be totally encased. Proper lubricating arrangements shall be provided for bearings and pinions. Gears shall be cut from forged steel blanks. Pinions shall be of heat treated alloy steel. Gears shall be as per BS 436/IS:4460.

(r)

(s) The trolley track wheels shall be rim toughened, heat treated carbon steel or low alloy steel or C.I. and shall be single flanged and shall have antifriction ball bearings. The wheels shall be machined on their treads to match the flanges of the track joints.

(t)

(u) The travelling trolley frame shall be made of rolled steel conforming to IS:2062. The side plates of trolley frame shall extend beyond wheel flanges, thus providing bumper protection for the wheels. The two side plates shall be connected by means of an equalizing pin.

(v)

(w) Axles and shafts shall be made of carbon steel and shall be accurately machined and properly supported.

(x)

(y) The lifting hooks shall be forged, heat treated alloy or carbon steel of rugged construction. They shall be of single hook type provided with a standard depress type safety latch. They shall swivel and operate on antifriction bearings with hardened races. Locks to prevent hooks from swiveling shall be provided. Hook shall be as per BS:2903/IS:3815

(z)

(aa) The brake for the lifting gear shall be automatic and always in action. It shall be of screw and friction disc type self actuating load pressure brake. Brakes shall offer no resistance during hoisting.

(bb)

(cc)

(dd)

(ee)

(ff) Electrically Operated Hoists

(gg)

(hh) Electric hoists shall be complete with hoisting motor, wire rope drum, wire rope, hook, necessary gearing, sheaves, electromagnetic brake for hoisting motion, weather & dust-proof push button station, contractor panel, all wiring, limit switches, etc.

(ii) Electric hoists shall conform to IS:3938 and shall be suitable for outdoor application. All the parts of the hoist shall be designed to withstand surrounding atmospheric conditions without any deterioration.

(jj)

(kk) Rope drums shall be either cast or welded to sustain concentrated loads resulting from rope pull. Drums shall be machine grooved right and left with grooves of a proper shape for the rope used.

(ll)

(mm) Gears shall be cut from solid cast or forged steel blanks or shall be of stress relieved welded steel construction or built up from steel billets and welded together to form a one piece gear section. Hoist ropes shall be extra flexible, improved plough steel rope with a well lubricated hemp core and having six strands of 37 a wires per strand with minimum ultimate tensile strength of 1.6 x 106 KN / Sq.m.

(nn)

(oo) Hooks shall be solid, forged, heat treated alloy or carbon steel of rugged construction of the single hook type and provided with a standard depress type safety latch.

(pp)

(qq) Hoisting motor shall be equipped with electrically released, spring set, friction shoe type brakes having torque capable of holding 125% of the full rated hook load. Brake shall apply when either the motor controller or the main power switch is in 'OFF' position or in the event of power failure/

(rr)

(ss) Drive motors shall be designed for frequent reversal, braking and acceleration and shall be as per IS:325. Pendant control switch, controllers and resistors, controls, electrical protective devices, cables and conductors, earthing guards etc. shall be as per IS:3938. Limit switches shall be provided for over-hoisting and over-lowering.

(a) The electric hoists shall be of Class II duty.

(b)

(c) 25% overload test, speed tests, limit switch tests and brake test shall be conducted for the hoist and trolley at manufacturer's works.

(d)

(e) Hand Operated Hoists and Trolleys

(f)

(g) Manual hoists shall be complete with hand-chain, trolley, pulley block, hook, hand and load chains, brake and other accessories. They shall comply with the latest applicable standards, regulations and safety codes in the locality where equipment will be installed.

(h)

(i) Each hoist shall be operated on a monorail (I-Beam). The factor of safety shall not be less than 5. The load chain may be heat treated to give ductility, toughness and conforming to I.S. 3109/B.S.1663/B.S.3114. The load wheel is to be made from heavy duty malleable castings. The hand chain is to Conform with B.S. 6405:1984 and hand chain wheel may be made from pressed sheet steel with roller type guarding. Gears shall be cut from solid cast or forged steel blanks or shall be stress relieved welded steel construction.

(j)

(k) Pinions shall be of forged carbon or heat treated alloy steel. Strength, Quality of Steel, heat treatment, face, pitch of teeth and design shall confirm to BS-436, BS-545 and BS-721. Spur and helical gears must comply with B.S. 436 and worm with B.S. 721. Bearing must be ball and roller type conforming to I.S. 2513/B.S., 2525-32:1954.

(l)

(m) Proper lubricating arrangements are to be provided for bearings and pinions. The brake for the lifting gear shall be automatic and always in action.

(n)

(o) The proof testing of each chain pulley block is to be carried out as per latest applicable standards. The safe working load is to be marked in such way that is clearly visible from the operating level.

(p)

(q) Electrically Operated Overhead Travelling Crane

(r)

(s) The crane shall be electrically operated, bridge type complete with all accessories including down shop conductor, crane rails and fixtures, and shall conform to BS 2573,IS:3177 or relevant internationally approved standards.

(t)

(u) The crane bridge shall consist of bridge girders on which a wheeled trolley is to run. The bridge trucks and trolley frames shall be fabricated from structural steel. Access walkway with safe hand railing

as is required along the full span length of the bridge girder. Steel shall be tested quality conforming to ASTM A36 except that, plates more than 20 mm thick shall conform to IS:2062,BS:4360 or relevant internationally approved standards.

(v)

(w) The bridge shall be designed to carry safely the loads specified in IS:807, BS:2573 or relevant internationally approved standards. All anti-friction bearings for bridge and trolley track wheels, gear boxes and bottom sheaves on hook shall be lubricated manually by hand operated grease pump through respective grease nipples.

(x)

(y) Wheel base and structural frame of the wheel mounting of the end carriages shall be designed so as to ensure that the crane remains square and prevent skewness. Bridge and trolley track wheels shall be of forged steel and shall be double flanged type. The wheel diameter and rail sizes shall be suitable for the wheel loads.

(z)

(aa) The crane rails shall be manufactured from wear resistant austenitic manganese steel. Mountings of the wheels shall be designed to facilitate easy removal for maintenance. Walkways shall be at least 500 mm clear inside width with a 6 mm thick non-skid steel plate surface. Steel rail stops to prevent rails from creeping and trolley from running off the bridge shall be abutted against ends of rails and welded to the girders. Bridge and trolley stops to match the wheel radius shall be provided before the buffer stops.

(bb)

(cc) All exposed couplings, shafts, gear, wheels, pinions and chain drives etc. shall be safely encased and guarded completely to prevent any hazard to persons working around. All bearings and gears shall have a design life of 100000 hours. Electro-magnetic and hydraulic thrustor brake shall be provided for the main hoist. One electro-magnetic brake shall be provided for each of the cross travel and long travel motions.

(dd)

(ee) Hook shall be solid forged, heat treated alloy or carbon steel suitable for the duty service. They shall have swivels and operate on ball thrust bearings with hardened races. The lifting hooks shall comply with the requirements of IS 8610 or BS:2903 / BS:3017 or relevant internationally approved standards and shall have a safety latch to prevent rope coming off the hook.

(ff)

(gg) Hoist rope shall be extra flexible, improved plough galvanized steel rope with well lubricated hemp core and having six strands of 37 wires per stand with minimum ultimate tensile strength of 1.6 X 106 kN/m2 of Right Hand Ordinary (RHO) lay construction. The ropes shall have a 6:1 safety factor on the specified safe working load, and shall conform to IS:2266. Rope drums shall

be grooved and shall be either cast iron or cast steel of or welded steel conforming to IS:3177, BS:466 or relevant internationally approved standards.

(hh)

(ii) Gears shall be cut from solid cast or forged steel blanks or shall be stress relieved welded steel construction. Pinions shall be of forged carbon or heat treated alloy steel. Strength, quality of steel, heat treatment, face, pitch of teeth and design shall conform to BS:436, IS:4460 and BS: 721 or relevant internationally approved standards.

(jj)

(kk) Name Plate showing the capacity, year of manufacture and rated capacity of hoist in figures not less than 150 mm height shall be placed on each side of the crane girder.

(ll)

(mm) The maximum deflection under full load shall not exceed 1/900 of the span (as per IS: 3177).

(nn)

(oo) All accessory and auxiliary electrical equipment including drive motors, electrically operated brakes, controllers, resistors, conductors, insulators, current collectors, pendant push button station, protective devices, operating devices, cables, conduits, etc. necessary for the safe and satisfactory operation of the crane shall be provided. (Power to the crane shall be provided by down shop conductors manufactured from high conductivity hard drawn copper. Conductors shall be completely shrouded such that they have no exposed current carrying surfaces.

(pp)

(qq) Pendant type push button station shall be sheet steel enclosed and shall comprise the following push buttons and indicating lamps:

(rr)

(ss) `Start' and `Stop'.

(tt) Long travel - `Right' and `Left'.

(uu) Cross travel - `To' and `Fro'.

(vv) Hook - `Hoist' and `Lower'.

(ww) Red indicating lamp for supply `ON' indication.

(xx)

(yy) Pendant type push button shall be supported independently of the electrical cable and shall be earthed separately, independent of the suspension. Automatic reset type of limit switches shall be provided to prevent overtravel for each of the following:

(zz)

(aaa) For `UP' and `Down' motions of the hook.

(bbb) Long travel motion

(ccc) Cross travel motion

(ddd)

(eee) Crane structures, motor frames and metal cases of all electrical equipment including metal conduit and cable guards shall be earthed. All motors, brakes, limit switches, panels, drum controllers, resistor unit sets shall be provided with two studs for earthing.

(fff)

(ggg) The crane, and all slings, ropes, shackles and other lifting equipment supplied shall be tested by the manufacturer at his works. The tests shall be carried out at 125% of Safe Working Load, and Test Certificates shall be supplied.

(hhh)

(iii) All motors shall be of the quick reversing type with electric mechanical brakes suitable for the duties specified. All movements shall be electrically powered suitable for operating with the hook loaded. Facilities shall be provided for the accurate location of the hook by means of `inching' the cross travel and down shop travel motions.

(jjj)

(kkk) Sufficient slings, ropes, shackles, lifting beams, etc shall be supplied to handle all items of plant covered by the crane. They shall be labelled or marked with the Safe Working Load (SWL) and the purpose for which they are intended.

(lll)

(mmm) The Contractor shall include with the cranes all necessary contactors, control cubicles and protection equipment necessary to operate the crane and provide adequate electrical protection against overload, phase and earth fault and fail-safe protection in the event of an interruption in the power supplies. All access ladders and platforms necessary to carry out maintenance and repairs shall be provided and installed by the Contractor.

(nnn)

(ooo) All electrical equipment shall be fully tropicalised.

(ppp)

(qqq) Site tests shall be carried out by the Contractor who shall supply the necessary materials for the test load. The test load shall be removed from site by the Contractor after successful tests have been carried out.

(rrr)

3.10 Jib cranes

(a) Fixed Jib Cranes shall be provided in the lowering/removal of equipments/parts to/from the clarifier floor and transferring the same outside the clarifier area. The Jib Crane capacity shall be 1.25 times the maximum weight to be handled in the clarifier or 1.5 Tonnes whichever is maximum.

(b) The lift and reach of the cranes shall be suitable for the clarifier offered. The crane shall be capable of being swivelled by 360°. Adjacent halves of clarifiers may be provided with common jib crane if feasible.

(c) All materials used in the construction shall be corrosion resistant. Mild steel used shall be galvanised. Ropes, chains and pulleys shall be of stainless steel construction. Hardware shall be of SS 316. The Jib crane shall also be provided for handling submersible mixers in Pre-Anoxic Tank and Anaerobic Tank.

3.11 Grit Removing Equipment

(a) The grit removing mechanism shall be of moving rake type to collect and removal settled grit effectively, with proper circumferential speed, and it shall be installed grit chambers. Each of the grit collector in the chambers shall be equipped with the following mechanism :

(i) Mechanical support beams.
(ii) Rotating vertical pipe shaft.
(iii) Torque arms, rake blades and scoops.

(b) Drive head along with induction motor with mechanical indicating arrangement shall be provided. Mechanical trip contacts and electrical overload relays shall be provided. One set of push button shall be provided near the motor.

(c) Classifier Mechanism :

The mechanism shall consist of the followings:

(i) Chain and sprocket with guard.
(ii) Reciprocating rake with hangers or screw mechanism.
(iii) A.C. motor.
(iv) Local push button shall be provided.

(d) Organic Return Pump

Each of the grit removal equipment shall be provided the Vertical propeller pump with suitable motor, starter, etc. shall be provided. The design of the pump and the piping on the inlet and outlet side has to be such that there are minimum number of bends as they are liable to be choked with organic matter. One set of push button shall be provided

near the pump set and one starter in the terminal sewage pumping station. The suspended organic matter washed in the degritting system will be returned to the distribution chamber. Impeller shall be of SS CF8M and shaft shall be of SS 316.

(e) In the event of tripping of working grit equipment drive (motor), the sizing of this equipment (including motor) shall be done in such a way that it shall take the overhead to remove the excess grit collected after starting of the tripped grit removal equipment.

0 Fine Bubble Membrane Diffusers

Provide a removable header arrangement that provides complete mixing of basin contents.

Space diffusers evenly along each header to provide full floor coverage.

Furnish all components necessary to provide a complete mixing system within each Pre-Aeration Tank. Work shall include but not necessarily be limited to the following:

Flanged connections (SS 316) at the upstream side of each drop leg for connection to an isolation butterfly valve.
Stainless steel Drop legs (SS 316).
Slip joint connections to the air distribution header (SS 316).
Stainless steel Air distribution headers (SS 316).
Diffuser connectors (SS 316).
Diffusers (Cylindrical, elastically membrane type) in silicon rubber material with anti-microbial coating.
Anchored Supports (SS 316)
Gaskets.
Header joints (SS 316).
Bolts, nuts and washers (SS 316).

Space diffusers evenly along the air headers.

Provide two tubular diffusers at each header connection. Mount to a reinforced tee located on the bottom centerline of the header. The reinforced Tee shall be adjustable to allow accurate alignment of the diffuser.

The Diffusers should be able to withstand high blower air and water temperature.

0 Diffuser Assembly

~~Field Oxygen transfer efficiency: minimum 18.0 %.~~
~~Non-clog, tubular design with inverted air reservoir.~~
~~Bottom deflector to prevent debris from entering diffuser assembly.~~
~~Full profile end caps to prevent air blow off.~~
~~316L Stainless Steel construction.~~
~~Minimum length : 650 mm.~~
~~Installation pitch : 100 -600 mm.~~
~~Provide orifice flow control to ensure orifice head loss is at least 2.5 times the head loss in the air header at all air flow rates in the diffuser's design operating range.~~
~~Space diffusers along air header to provide uniform mixing of the pre-aeration tank contents.~~

0.2A~~ir Header and Droplegs~~

~~(a) Header and drop legs shall be constructed of 316L stainless steel.~~

~~1. Fabricate air distribution header in sections up to a maximum of 12 meters in length.~~
~~2. Bottom elevation of the air distribution header shall be same throughout the tank.~~
~~3. Provide removable end cap at header ends.~~
~~4. Design connections between sections of the air distribution header to allow individual header sections to rotate independently of adjacent header sections.~~
~~5. Header dimensions shall conform to dimensional tolerances specified in ASTM A554-89 and ASTM A530-87.~~

~~(b) Furnish a drop leg from the air main connection at the top of the tank.~~

~~1. Provide a slip joint connection between the drop leg and distribution header.~~
~~2. Support the drop leg from the connection at the air header.~~

~~(c) Use factory welding only; field welding shall not be allowed.~~

~~1. Wire brush outside of each weld area.~~
~~2. Remove all discoloration and deposits left by welding by pickling.~~

3. Factory weld all diffuser connections. Stiffen both the diffuser connectors and the headers to withstand a moment of 56.5 N.m at the connector without permanent deformation.

(d) Passivate all SS 316 assemblies and parts after fabrication by immersion in a pickling solution of 6 percent nitric acid and 3 percent hydrofluoric acid at 60° C for a minimum of 15 minutes.

1. Neutralize by immersion in a tri-sodium phosphate rinse.
2. Submit certificate that this has been done.

0.3Supports and Anchors

(a) Provide wall and floor mounting supports for all drop legs and air headers as necessary to anchor firmly on the wall and to the bottom of the tank and as specified herein.

(b) Anchor supports to concrete walls and floors using stainless steel expansion bolts sized and spaced as required for the loads encountered.

(c) Design supports to allow leveling the air header and diffuser assemblies to within specified tolerances.

(d) Provide expansion couplings in the drop legs and air headers as necessary to accommodate anticipated thermal expansion and contraction.

1. The raw wastewater temperature is expected to vary between 20 and 35 degrees Centigrade.
2. The ambient air temperature is expected to vary between 20 and 36 degrees Centigrade.
3. The aeration air will be compressed to a pressure of approximately 0.55 bar.
4. Submit expansion coupling design as well as computations for sizing.

Spare Parts

Provide spare parts in the quantities indicated.

Item	Quantity
Diffuser Assemblies	10%
Orifice Inserts	10%

0Installation

(a) Install all components in accordance with the manufacturer's instructions and recommendations.

(b) Install all diffusers to within +/- 10 mm of a common horizontal plane.

0 Field testing

(a) All Fine bubble diffused aeration systems will be field tested.

(b) Testing will verify the installation as well as the diffuser's ability to deliver the specified air flow rates at the manufacturer's stated pressure loss. Testing will also verify the uniformity of mixing provided.

(c) Leveling tests:

Introduce clear water into each tank to the top of the diffuser elements. Check the level of the diffusers to document that all element horizontal surfaces are within 10 mm of a common horizontal place and at the specified elevation.

0.6Leakage and distribution of flow tests:

After successful completion of the leveling tests, raise the water level to 50mm above the manifold.

Visually inspect the water surface to ensure that the airflow is uniformly distributed across the tank.

Pressure test:

All of air supply pipe line shall be tested by pressure. Test pressure shall be at least 2 times higher than normal operation pressure.

If client is unsatisfied any test result, repeat the test until the installation is essentially void of air leaks.

Repair any leaks in the elements holders, elements, pipes or the like.

3.12.7Disc Fine Bubble Aeration System

Fine Bubble Tubular Membrane Diffusers

(a) Provide a retrievable arrangement that provides complete mixing and aeration of basin contents.

(b) Space diffusers evenly along each header.

(c) Furnish all components necessary to provide a complete mixing and aeration system. Work shall include but not necessarily be limited to the following:

- ✓ Flanged connections (SS 316) at the upstream side of each drop leg for connection to an isolation double flanged metal seated Butterfly Valve Gear operated.
- ✓ Stainless steel Drop legs (SS 316).
- ✓ Slip joint connections to the air distribution header (SS 316).
- ✓ Stainless steel Air distribution headers (SS 316).
- ✓ Diffuser connectors (SS 316).
- ✓ Tubular diffuser assemblies with silicone elastomer membranes with anti-microbial coating.
- ✓ Anchored Supports (SS 316) as necessary.
- ✓ Gaskets.
- ✓ Header joints (SS 316).
- ✓ Bolts, nuts and washers (SS 316).

(d) Provide two tubular diffusers at each header connection. Mount to a reinforced tee located on the bottom centerline of the header. The reinforced Tee shall be adjustable to allow accurate alignment of the diffuser.

(e) The Diffusers should be able to withstand high blower air and water temperature.

3.12.1 Diffuser Assembly

- ✓ Provide orifice flow control to ensure orifice head loss is at least 2.5 times the head loss in the air header at all air flow rates in the diffuser's design operating range.

3.12.2 Air Header and Droplegs

(a) Header and drop legs shall be constructed of 316 stainless steel.

1. Bottom elevation of the air distribution header shall be same throughout the tank.
2. Design connections between sections of the air distribution header to allow individual header sections to rotate independently of adjacent header sections.
3. Header dimensions shall conform to dimensional tolerances specified in ASTM A554-89 and ASTM A530-87.

(b) Furnish a drop leg from the air main connection at the top of the tank.

1. Provide a slip joint connection between the drop leg and distribution header.
2. Support the drop leg from the connection at the air header.

(c) Use factory welding only; field welding shall not be allowed.

1. Wire brush outside of each weld area.
2. Remove all discoloration and deposits left by welding by pickling.
3. Factory weld all diffuser connections. Stiffen both the diffuser connectors and the headers to withstand a moment of 56.5 N.m at the connector without permanent deformation.

(d) Passivate all SS 316 assemblies and parts after fabrication by immersion in a pickling solution of 6 percent nitric acid and 3 percent hydrofluoric acid at 60˚ C for a minimum of 15 minutes.

1. Neutralize by immersion in a tri-sodium phosphate rinse.
2. Submit certificate that this has been done.

3.12.3 Supports and Anchors

(a) Provide wall and floor mounting supports for all drop legs and air headers as necessary to anchor firmly on the wall and to the bottom of the tank and as specified herein.

(b) Anchor supports to concrete walls and floors using stainless steel expansion bolts sized and spaced as required for the loads encountered.

(c) Design supports to allow leveling the air header and diffuser assemblies to within specified tolerances.

(d) Provide expansion couplings in the drop legs and air headers as necessary to accommodate anticipated thermal expansion and contraction.

1. Submit expansion coupling design as well as computations for sizing.

3.12.4 Installation

(a) Install all components in accordance with the manufacturer's instructions and recommendations.

(b) Install all diffusers to within +/- 10 mm of a common horizontal plane.

3.12.5 Field testing

(a) All Fine bubble diffused aeration systems will be field tested.

(b) Testing will verify the installation as well as the diffuser's ability to deliver the specified air flow rates at the manufacturer's stated pressure loss. Testing will also verify the uniformity of mixing provided.

(c) Leveling tests:

3. Introduce clear water into each tank to the top of the diffuser elements.
4. Check the level of the diffusers to document that all element horizontal surfaces are within 10 mm of a common horizontal place and at the specified elevation.

3.12.6 Leakage and distribution of flow tests:

(a) After successful completion of the leveling tests, raise the water level to 50mm above the manifold.

(b) Visually inspect the water surface to ensure that the airflow is uniformly distributed across the tank.

(c) Pressure test:

All of air supply pipe line shall be tested by pressure. Test pressure shall be at least 2 times higher than normal operation pressure.

(d) If client is unsatisfied any test result, repeat the test until the installation is essentially void of air leaks.

(e) Repair any leaks in the elements holders, elements, pipes or the like.

Design: The Disc membrane diffuser shall be developed specifically for Releases 1~3mm fine bubble in the wastewater treatment plant. All materials have been selected for their ability to withstand the effects of the chemical, bio-chemical agents and 0~100°C used in wastewater tank. The diffuser can be placed in an evenly distributed grid system over the entire aeration tank bottom. Air can be easily through the air orifice and integrated non-return valve into the wastewater. The air orifice design to maintain the diffuser standard airflow input prevented the max. air enter to damage diffuser membrane. The membrane shall be secured onto the support dish with a constrict flex rim and retaining ring designed to increase the tension on the point of engagement as the diffuser air rate increases.

Construction: The materials of construction for both support dish and membrane diaphragm are non-corrosive and UV resistant. The support dish shall be upward facing convex plastic (Glass filled reinforced Polypropylene) for working without any acid dosing requirements and integrated non-return valve designed for back-flow prevention while airflow is interrupted. The membrane diaphragm which covers the dish is made of high grade EPDM resistant to the usual sewage ingredients. The membrane shall be further fastened to the support dish with a U-type retaining ring without special tools for fastening or replacement the membrane.

Aeration system shall be retrievable grid, membrane disc fine bubble aeration system –

The fine bubble aeration system will comprise:

Stainless steel (SS316) droplegs and Headers.

ü PVC manifolds and air distributors.

ü PVC diffuser holders and retainer rings.

ü Stainless steel supports and anchors –

ü Bolts, nuts and gaskets for aeration system flange connections.

ü Air distributor purge systems.

ü Membrane disc diffusers with integral O-ring gaskets and subplates.

The following design features will be incorporated in the fine bubble aeration system: –

· Fabricated manifold with fixed threaded union joints for connection to the air distributors.

· Manifold sections connected with fixed threaded union or flanged joints to prevent rotation or blow apart.

- Manifold, distributor connections and supports designed to resist thrust generated by expansion/contraction of the air distributors over a temperature range of 70°C
- Air distributors perpendicular to the air manifold
- Fabricated distributors with single diffuser holders solvent welded to the crown of the air distributor for complete air seal and strength.
- Distributors and holders designed to resist a dead load of 90kg applied vertically to the outer edge of the diffuser holder.
- Air distributor sections joined with positive locking fixed threaded union or flange type joints for all submerged header joints to prevent blow apart and rotation. Bell and spigot, slip on or expansion type joints are not acceptable for submerged joints.
- Threaded union joints designed with spigot section connected to one end of the distribution header, a threaded socket section connected to the mating distribution header, an "O" ring gasket and a threaded screw on retainer ring. Solvent welding shall be done in the factory.
- Air distributor support spacing at a maximum of 2400mm.
- All supports designed to allow for thermal expansion and contraction forces over a temperature range of 70°C and to minimize stress build up in the piping system
- Supports designed to be adjustable without removing the air distributor from the support.
- Diffuser assembly comprising: diffuser membrane with integral 'O' ring, sub-plate, holder, retaining ring and air flow control orifice.
- Integral check valve incorporated into the membrane diffuser assembly
- PVC support plate incorporated to form an air plenum under the diffuser and support for the membrane when the air is off
- Retainer ring threads designed with minimum cross section of 3mm and to allow for one complete turn to engage threads.
- A liquid purge system to drain the entire submerged aeration piping system for each aeration grid including airlift purge eductor line and manual control valve.
- Two parts by weight of titanium dioxide per 100 parts of resin will be added to PVC compounds for manifolds, air distributors, joints and PVC diffuser assembly components to minimize ultraviolet light degradation.
- All PVC joints will be factory solvent welded. Field solvent welding will NOT be permitted.
- Circular membrane diffuser discs with integral O ring will be manufactured of EPDM synthetic rubber compound with precision die formed slits. Thermoplastic materials (i.e. plasticized PVC or polyurethane) are not acceptable.
- Carbon black will be added to the EPDM material for resistance to ultraviolet light.

- The maximum tensile stress on the diffuser will be limited to 10 psi (69 kPa) when operating at 2.4 SCFM/sq. ft. (43.9 Sm 3 /h per m 2) of material. Proportionately thicker material is to be furnished for larger diameter disc diffusers to limit the maximum tensile stress and to resist stretching.

- Supports and anchors, spare parts,installation method, field testing, leakage and flow distribution tests shall be same as per above clause no.s 8.18.3 to 8.18.7.

3.13 Air Blowers

High Speed Turbo Blower

Turbo blowers are single-stage, high speed gear less air cooled radial turbo blowers designed to meet varying flow and pressure requirements in various processes. Blower is a modern frequency controlled, gear less driven machine along with lubricant-free aerodynamic bearings, guarantees an economical, reliable and maintenance-free operation.

Turbo Blowers employ the high precision machined cast impellers, hydrodynamic air foil bearings (air-lubricated), highly efficient Permanent Magnet motors and sensor-less Invertor drives, which eliminate the complicated gear trains or pulley & belt to provide considerable energy savings without much scheduled maintenance and with very low level of noise. Acoustically enclosed unit with noise not exceeding 80 dB at distance of 1 meter from periphery of the Blower unit.

A. Permanent Magnet (PM) Motor

The Blower shall be driven with Permanent Magnet motor. The rotor of the motor has built-in permanent magnet; the power is required only to rotate the shaft. With the rotor being specifically designed to rotate at high speed, the size of the rotor is small. Rotor shall be of titanium & inconel alloy is lighter in weight. Because of these two factors the twisting torque is comparatively very small. The high electric grade material & high rotating speed produce less heat & hence cooling energy required is comparatively lower. PM Motor shall be synchronous motor, which has no slip & hence power factor shall be high. The efficiency is consistently maintained more than 95% from full load to partial load conditions. The PM motor is entirely air cooled and capable of a wide range of operating speed. Integrated variable speed drive ensuring starting current of the PMS motor to be less than 10% of the full load current. Current (Ampere) based active control should be used to enable high rise-to-surge.

B. Frequency Inverter

The frequency inverter, DC choke and RFI filter are standard and integrated in the Turbo Blower package. Other types of harmonic filters shall be supplied as per site conditions.

C. Air Foil Bearings

Air bearings shall not come in any physical contacts when shaft is in motion, which doesn't require any lubricant. The Air Foil bearings are of aerodynamic bearings. At standstill (idle mode) the shaft sits on a foil tightened by springs. During operation, due to shaft rotation a cushion of air is generated between the foil and shaft which maintains the shaft in suspension without any need for an external source of compressed air. This increases energy efficiency. The bearings are not lubricated and the system is absolutely oil-free.

D. Impeller & Casing

The impeller is directly mounted on the shaft of the motor. The impeller is made up of machined cast stainless steel Gr. SUS630 having high structural strength /Aluminum alloy material. The profile is backward leaning to provide larger flow capacity, wide operating flow range & high efficiency.

The impeller alone is first dynamically balanced & again dynamically balanced together after mounting on the shaft. The spiral casing and the blower bellmouth are made of cast aluminum, while the discharge connection is made from Stainless steel.

E. HMI Display

HMI display indicates the Discharge Pressure, Inlet Temperature, Discharge Temperature, Flow Rate, Power consumed, Speed and the across the inlet filters. It shall also display the performance curve with the actual operating point in it. HMI Touch Screen Graphical Display with on-line performance curve showing Pressure v/s Flow, Operating Point.

HMI should provide on-line display of instantaneous values & trending of following parameters: Pressure Drop across Suction Filters, Suction Air Temperature, Discharge Air Temperature, Discharge Air Pressure, Input Power & Dissolved Oxygen; RPM, Run Hours with facility for MODBUS connectivity to SCADA to display these parameters. Facility for remote control of pressure, flow, power, D.O. parameters shall also be provided. Integrated Mass Flow Meter for instantaneous on-line flow measurement with +/- 1% accuracy.

The following operation mode can be selected from HMI.

a. Constant Current

b. Constant Pressure

c. Constant Volumetric Flow

d. Constant Oxygen (Dissolved Oxygen Control)

F. Acoustical Enclosure

(a) Provide a factory assembled acoustical enclosure around the entire blower. Disassemble the enclosure as necessary for shipment. Provide either removable or hinged doors for access to all blower parts and components for servicing and maintenance. Size access panels to allow easy access by a single operator. Hinges, fasteners and appurtenances shall be stainless steel. Provide clear, transparent Lexan or plastic windows to visually observe gauges.

(b) Mount an auxiliary exhaust fan and thermostat on the acoustical enclosure to provide air circulation after blower shutdown or when the temperature inside the enclosure exceeds 40°C.

(c) The free field A-weighted sound pressure level measured in four quadrants at 1 metre distance from the enclosure shall average 80 dBA, or less. Measure with a Type 1 instrument suited for checking compliance with Environmental and Occupational Noise Rating Recommendations.

All the accessories shall be complied as per specification mentioned in Centrifugal single stage blower.

(a) ~~Compressor blowers shall be of the tri lobe Roots type, each provided with inlet filter and silencer, pressure reducing valve, pressure gauges, pressure relief valve, drain, air flow indicator and acoustic bend or silencer in the delivery branch. Bearing housings and gear boxes shall be separated from the blower housings by air spaces. The units shall be complete with a self contained oil cooling system for the bearings. The blowers shall be housed in a separate sound proof room to reduce the noise level or inside acoustic enclosure. The noise level shall not exceed 90 dBA at 1 meter from the Blower.~~

~~(b)~~

~~(c) The bearings shall be generously designed to give long operational life. Bearings at the drive end may be oil or grease lubricated. The gears and bearings at the non drive end shall be oil lubricated. Bearings shall be~~

provided with oil throwers to prevent leakage of oil. The blower shall be arranged for horizontal inlet and vertical outlet, delivery velocity not exceeding 25 m/s and each blower shall be provided with following components but not limited to:

(d)

(e) Common base frame for Blower & Motor.

(f) Inlet silencer and filter.

(g) Discharge Silencer & non-return valve in delivery branch.

(h) Butterfly valves in both inlet and delivery branches.

(i) Pressure relief valve or excess pressure safety device.

(j) Bellows type couplings on inlet and delivery branches.

(k) Acoustics Enclosure.

(l) V Belt drive arrangement with Belt Guard.

(m) Isolating valves, Pressure reducing valves & Pressure gauges

(n) Air Flow meters, Temperature gauges.

(o) Water trap.

(p)

(q) The interconnecting pipe work shall be flanged to BS EN 1092-1/BS: 4504. A drain cock shall be provided at the lowest point in the each delivery pipe work along with reflux valve. Individual stop valves and safety valves shall be provided for each unit.

(r)

(s) Blowers shall be driven by squirrel cage motors through a matched V belt drive. Motors shall be mounted on slide rails mounted on a common bed plate, to facilitate the tensioning of the belts. Blowers shall not run above 1000 rpm.

(t)

(u) Each delivery branch shall include a drain at the lowest part and a reflux valve.

(v) Each blower shall contain one inlet air pressure, one discharge air pressure, and one discharge air temperature gauge. The pressure gauges shall be calibrated in kPa absolute and be of the compound type. The gauges shall have circular dials, minimum 100 mm diameter with black figures on white background. Pressure gauges shall be furnished with pulsation damper. Temperature gauges shall be manufactured with standard temperature bulb.

(w)

(x) Appropriate cooling arrangement shall be provided at the blower discharge line so as to bring down the outlet air temperature within tolerable limits, so as to safeguard the life of fine bubble diffusers and satisfactory performance of the same.

(y)

(z) Acoustical Enclosure

(aa)

(bb) Provide a factory assembled acoustical enclosure around the entire blower. Disassemble the enclosure as necessary for shipment. Provide either removable or hinged doors for access to all blower parts and components for servicing and maintenance. Size access panels to allow easy access by a single operator. Hinges, fasteners and appurtenances shall be stainless steel.

(cc)

(dd) Provide clear, transparent Lexan or plastic windows to visually observe gauges and lever arms of the variable guide vanes and diffusers.

(ee)

(ff) Mount an auxiliary exhaust fan and thermostat on the acoustical enclosure to provide air circulation after blower shutdown or when the temperature inside the enclosure exceeds 40°C.

(d) The free field A-weighted sound pressure level measured in four quadrants at 1 metre distance from the enclosure shall average 85 dBA, or less. Measure with a Type 1 instrument suited for checking compliance with Environmental and Occupational Noise Rating Recommendations.

(e)

3.14 Submersible Mixer

(a) The submersible mixer shall be installed in the Anaerobic and anoxic zones, and they shall be capable of providing a velocity gradient in the range of 500 to 1000 mm/sec.

(b) The mixer shall have a self-cleaning propeller optimised for effective mixing and vibration-free running, and required power shall be at least 10Watt/m^3 of tank volume.

(c) The mixer shall be driven by a high efficiency 3 phase motors IP68 Class F. Motor shaft and rotor shall be dynamically balanced.

(d) Bearings shall be lubricated-for-life with a calculated life of more than 100,000 operating hours.

(e) The mixers shall have the flexibility to be located at different depths and thereby avoiding dead zones.

(f) The mixer shall be provided with the following :

(1) Lifting frame with a winch which can be dismantled, fee standing with adjustable boom length.

(2) Mounting socket for free standing hoist suitable for wall mounting.

(3) Guide for floor fixing components and support brackets for wall mounting.

(4) Stainless steel rope for raising and lowering the mixer.

(5) Rope block for holding the stainless steel rope where the lighting frame is used in different locations.

(6) Support rope for reliable support and guidance of power supply cable.

(7) Support clamps and hooks to support the power supply cable in such a manner that it is not under strain.

(g) The propeller, propeller shaft and motor housing shall all be of SS 316.

3.15 Primary and Secondary Clarifiers

Circular (radial), fixed bridge with scum collector, central turns table type or peripheral drive type , collecting effectively with proper circumferential speed, clarifiers shall be provided. The clarifier shall be rugged and robust in design and shall be provided with high capacity drive head and induction motor having high torque rating, centrally or peripherally located, with positive sludge raking by means of one or more raking arms. Both the raking arms should have scraper blades fitted at the bottom, so that the sludge from scraper blades is pushed to the sump on every rotation.

(a) The drive head mechanism arrangements shall consist of a turn table base casing mounted on top of the centre pier and shall have an angular ball bearing mounted internal gear that supports the under water mechanism. The pinion meshing with the internal gear should be driven through a worm gear reduction unit mounted on top of the turn table drive unit. The balls should ride on hardened steel strips set into grooves in the base and gear casing so that they can be readily replaced whenever required.

(b) The unit will have mechanical overload arrangement with a torque indicating arrangement along with necessary contacts for tripping the motor in the event of overloading. This condition shall be annunciated. The unit shall have push button station near the motor and starter with push button shall be provided in the control room, i.e. the terminal sewage pumping station or return activated sludge pump house along with necessary switches. The clarifier unit should also be provided with necessary M.S. scum trough, scum baffles, skimmer assembly, M.S. rake blades, arms and brass squeezes. The V-notch weirs shall be 6mm thick

of reinforced fiber glass with clamps etc. for making the necessary adjustments.

(c) The bridge connecting the periphery of the tank to centre pier shall have walkway covered with chequered plates and provided with hand railing on both sides.

(d) Corrosion allowance of 2mm shall be taken in the structural sections of scraper arm, bridge etc.

(e) Structural design calculations shall be submitted for all structures including scraper arm, bridge etc.

3.16 Gravity Thickeners

Circular (radial), fixed bridge, central turn table type or peripheral drive type picket fence, collecting effectively with proper circumferential speed, a clarifier shall be provided. The clarifier shall be rugged and robust in design and shall be provided with high capacity drive head and induction motor having high torque rating, centrally or peripherally located, with positive sludge raking by means of one or more raking arms. Both the raking arms should have scraper blades fitted at the bottom, so that the sludge from scraper blades is pushed to the sump on every rotation.

(a) The circular reinforced concrete thickeners tapering at bottom shall be provided for thickening process. The sludge laden suspension from Waste water balancing Tank shall be fed to thickeners.

(b) Design shall be such that the sludge can become compacted and can be extracted from the bottom. Interstitial liquid flows through peripheral weir at top. Tanks shall be deep enough to allow the sludge to settle. At least 50 cm freeboard shall be provided.. Provision shall be made to remove the sludge from top if there is a serious risk.

(c) Provision shall be made for collection of thickened sludge and pumping it to Centrifuge.
A full diameter bridge with central drive shall be provided with: central platform for the installation of the scrapers and their drives and for the local control panel; a radial scraper system with bottom scraper blades, suspended on the bridge.

(d) The thickeners shall have a full diameter fixed bridge complete with 1200mm walkway for personnel access to the centre, access stairs to ground level and hand railing, a motor driven sludge scraper complete with all necessary controls, delivery pipe work, a stilling well and overflow steel weir plates. Hand railing, walkways, access steps etc shall be galvanized. Handrails shall be of tubular construction and made of 32NBpipes.

(f) The scraping gear shall be supported from the tank base and from a fixed bridge carrying the central electrical drive for the rotating gear. The equipment including driving motor, gears, shafting and scrapers shall be designed for continuous operation and sized for the most arduous operating condition including starting from rest with an accumulation of sludge in the thickeners.

(g) The electric motor, gearbox etc., shall be provided with a sunshade.

(h) The fixed bridge, hand railing, access steps and the feed well shall be galvanized steel. The main drive shall be cast Iron construction and shall be enclosed in a dustproof enclosure with oil bath lubrication. All underwater hardware shall be of SS304.

(i) Suitable overload protection for the drive shall be provided to ensure that the sludge shall not overload the equipment and emergency stop push button shall be provided.

(j) The scrapers shall be fitted with rotation monitors and over torque protection to alarm in the event of a failure.

(1) Corrosion allowance of 2 mm shall be taken in the structural sections of scraper arm, bridge etc.

(2) Structural design calculations shall be submitted for all structures including scraper arm, bridge etc. and also the calculation for drive head selection including the Torque Rating.

(k) V-notch weir in Reinforced fiberglass construction of size minimum 5mm thick and 200 mm wide shall be provided along the launders for uniform draw-off of the overflow. The weir plate shall be fixed to the launder by means SS304 grade clamping plates and fasteners.

The hydraulic equipment will consists of the DI inlet pipe(runs along the bridge) to the central feed well of the thickener; sludge draw-off pipe

with an manual & Motorized Knife Gate valve (in SS CF8M material of construction) for intermittent operation according to an adjustable timer; a drain pipe with manually operated gate valve for the complete emptying of the unit; a discharge pipe/channel from the peripheral collecting channel to the main channel leading to the Supernatant sump.

(l) The sludge thickener mechanism shall be generally in MS galvanized construction, suitable for installation in a circular RCC tank and shall include the following:

a. Mechanism support beam spanning the diameter of the tank.
b. Walkway and handrail from the edge to the centre of the tank.
c. Drive mechanism with internal gear type.
d. Reduction gear box.
e. Chain and sprocket with guard.
f. Central shaft with scrapper arm and picket fence.
g. Skimmer Scum Baffle and Scum trough.
h. Overflow weir:
i. Vertical pickets.
j. Torque Indicating Device.
k. Overload Alarm protection.
l. Autolifting device.

Dewatering Centrifuges

The Dewatering Machine and its peripheral equipment shall include but not necessarily be limited to the following;

Powder or liquid Coagulant storage tanks.
Mixers and solution tanks.
Coagulant service tanks.
Supply line & flush line.
Chemical feeding pumps.
Water supply pumps.
Sludge feeding pumps.
Dewatering Centrifuge()
Belt conveyor.
Cake hopper.
Flow meters for feeding Sludge, and for feeding chemical solution.
Control valves on sludge feeding line, and on Chemical feeding line.
Drain system

Dewatered cake shall be conveyed by a belt conveyor to cake hopper for carrying out for reuse.

To select the type of dewatering machine, Contractor shall provide technical information to show client that performance to obtain his approval in advance.

Decanter Centrifuge

The centrifuge shall comprise a conical cylindrical bowl and scroll feed horizontally mounted in bearings on a frame. The centrifuge bowl and scroll support frame shall be mounted on a fabricated steel sub-frame.

The bowl and scroll shall be made from stainless steel SS316 material. The leading faces of the scroll shall be protected against abrasive wear by the application of a suitable hard-coated material.

The whole rotating assembly shall be enclosed by a carbon steel fabricated casing incorporating a Centrate discharge hopper and outlet pipe, and a rectangular solids hopper which shall discharge the dewatered sludge into the disposal system.

The rotor shall consist of a solid bowl which is conical-cylindrical in shape and which rotates about a central shaft. An inner scroll shall be provided to convey

separated sludge from the periphery of the cylindrical bowl to the beach at the conical end of the rotor.

The main scroll bearings shall be arranged for lubrication by an external lubrication system. Wherever practicable greasing nipples shall be arranged together as a battery. The complete rotating assembly shall be dynamically balanced and test certificates provided.

Sludge shall be fed into one end of the rotor through a centrally positioned feed tube and dispersed to the bowl through an inlet chamber.

The bowl shall be provided with an adjustable 360° peripheral weir at its cylindrical end to control the depth of the Centrate in the rotor.

The fixed outlet castings of the rotor shall be designed to collect the centrate and dewatered sludge from the rotor. Baffles within the casing shall direct the separate phases to the relevant discharge points and prevent cross-contamination.

The centrifuge shall be mounted on heavy duty vibration isolators, located between the machine and the supporting steelwork or foundations, to damp vibrations and prevent vibration transmission. Two axis vibration monitors shall be provided to stop the centrifuge automatically when excessive vibration is detected.

Flexible connections shall be provided on the sludge fed system and the Centrate system at the centrifuge. The dewatered sludge discharge system shall incorporate flexible chutes.

(i) Variable Speed Drive

A variable speed drive shall be provided to accelerate the rotor to operational speed and maintain that speed during the centrifuge's duty period. The bowl drive shall be electric or hydraulic and shall be coupled to the drive shaft by a multiple 'V' notch belt drive.

(ii)Differential Scroll Drive

The scroll drive shall be provided with a separate drive mechanism to control its rotation in the same direction but at a different speed to the outer bowl. The differential speed shall be adjustable.

The drive shall be linked to the main bowl drive by an epicyclic gearbox. The differential speed of the scroll shall be automatically and manually adjustable so that the moisture content of the dewatered sludge can be controlled as required.

For safe operation, contractor shall provide control panel showing proper Sequence of operation with interlocking.

Chutes and interconnecting piping shall be provided with flexible joint (minimum 10 mm flexible in all direction) to avoid vibration.

3.17 Conveyor System

For the disposal of sludge a common motor driven endless belt conveyor shall be provided. The conveyor shall be designed in accordance with IS 11592 or equivalent. The conveyor and chutes shall be suitable for handling occasional heavy objects which will cause shock loads.

The construction of the frame and support shall be robust and torque resistant. Belt conveyor shall be of 20 deg. Trough type complete with drive assembly structures, idlers, pulleys and belt cleaners. Idlers and pulley shall be provided with anti friction bearings.

The belt material shall be two ply nylon or equivalent with minimum 3 mm neoprene covering on carrying side. Splicing shall be employed to make the belt endless. The belt shall operate over three roll twenty degree, troughing idlers. The idlers shall rotate on precision type, deep groove, single row ball bearing with built in close fitting triple labyrinth grease seal. The ends of the outer shell shall be counter bored and a full length centre tube journalled concentricity. The outer shell, centre tube and precision die formed steel ends shall be brazed into an integral unit to provide concentricity. The ends of the centre tube shall be bored concentrically with each other after roll assembly to provide correct bearing alignment and to provide prestressing of boring. The centre tube shall be grease fit after assembly. Troughing idlers shall have means of adjustment or ensuring belt tracking. On the return run the belt shall operate over flat roll idlers having bearing, shaft and lubrication arrangements as above for carrying idlers. Spacing of idlers shall be of 1200 mm on carrying run and 2400 mm on return run.

The head and tail pulleys shall be manufactured from welded steel/any alloy steel and shall be provided with rubber lagging. Lagging for drive pulleys shall have herringbone grooving. Pulleys shall be equipped with taper lock bushings. The tail pulley shall incorporate a screw rake for adjusting belt tension. Head and tail pulleys shall be adequately guarded.

Shafting for pulleys shall be of heat treated carbon steel. They shall be forged, ground and polished to obtain close diameter tolerances. The head shaft shall be provided with roller bearing pillow blocks.

The belt conveyor shall be driven by a squirrel cage, TEFC motor. A V belt drive arrangement shall be provided between the motor and a helical speed reducer, the latter shall be mounted on the end of the head shaft. The driving pulley shaft shall have back stops to prevent backward movement of the belt.

The conveyor shall be supported on appropriate channel sections with 14 gauge steel deck plate between the two runs of the belt and the necessary supports to the floor. The floor supports shall be made out of steel plates having minimum 6 mm thickness. The conveyor shall be protected from weather by a 'dog box' type canopy.

An adjustable belt scraper shall be provided on the hopper end of the conveyor belt. The scraper and attachments shall be of fiberglass/fibre reinforced plastic/PVC.

Sludge cake discharge Hoppers shall be provided to transfer the sludge cake from the Centrifuge to the troughed belt conveyor and from the conveyor discharge to skip. The latter chute shall extend beneath the belt scraper and shall allow access for maintenance of the belt scraper. Chutes shall be designed to minimize the accumulation of rags and stringy materials.

The conveyor shall be fitted with an emergency stop operated by wire rope at foot level. Two Nos. belt sway switches shall be provided on conveyor.

3.17 Primary Sludge Pumps (Progressing – Cavity Pumps)

(a) Pumps shall be of the type in which a pumping action is generated by a helical rotating eccentrically within a resilient stator in the form of a double internal helix. The eccentric motion of the rotor shall maintain a constant seal across the stator as it travels through the pump to give a uniform positive displacement.

(b) Pumps shall be arranged generally with a single shaft seal at the suction end. Mechanical seals shall be used. If a flexible shaft is used to accommodate the eccentric motion, a corrosion resistant shroud shall be fitted to prevent fiber build-up on the shaft. Enlarged inspection access

holes shall be fitted to the suction chambers of all pumps for periodic removal of accumulated debris. The shaft bearing shall be positively isolated from the fluid being pumped.

(c) The rotor material shall be selected for corrosion and abrasion resistance for the fluid being pumped, and for prolonged service life. Hard chrome or other approved coatings shall be not less than 250 micron thickness and shall be diffused in to the base material. The rotor shall

Generally be single-stage and shall incorporate not less than 3600 of twist, but for high-head applications, it may be necessary to use more than a single-stage. The stator shall be of a resilient material selected for chemical and abrasion resistance for the fluid being pumped. Pump speed shall suit the application, where variable delivery output is needed; the pump shall be provided with a variable-speed drive. The size and speed range of the pump shall ensure that the highest expected duty point shall lie within the available speed range.

(d) Pumps shall normally be driven by a fixed-speed electric motor through reduction gearing and the combined drive shall be continuously rated. Pump and motor shall preferably be mounted in-line on a common base plate. Alternatively, the drive motor may be top-mounted above the pump to minimize floor area, and shall be connected by external V-belts and pulleys. V-belt drives shall have full guards of the type that allow the belts observed without removal of the guard. Facilities shall be provided for ready adjustment of belt tension.

(e) Coupling guards shall be provided, which shall be rigid, securely fixed, and designed so that removal is not necessary during normal operation, routine maintenance and routine inspections.

(f) All motor enclosures shall be provided with ingress protection to IP55. Motor anti-condensation heaters shall be provided and shall be suitable for use on a 220V single-phase, 50Hz supply. All bearing shall have a B10 design life of not less than 40,000 running hours and shall be designed for loading 20% in excess of calculated maximum loading.

(g) The motor shall be driven with VFD drive.

(h) Pumps shall be fitted with individual dry-running protection to initiate pump trip. Dry-running protection by 'under-current' monitoring or 'pipeline-intrusive' device shall not be used.

Material of Construction;

S. No.	Component	Material
1	Pump Housing	CI IS210 Grade220 or 260
2	Rotor	SS AISI 316(HCP)
3	Shaft	SS AISI 316(HCP)
4	Stator	Nitrite black
5	Type of drive	V belt & Pulleys
6	Base plate	MS fabricated
7	Seal type	Gland packing

6.29 Sludge Digester and Bio Gas Peripheral Equipment

The sludge digester sytem shall consist of anaerobic digester, , and sludge tank along with gas bell. The sludge digester shall produce bio gas for gas mixing and digester heating boiler, and for power generation in the future. The boiler shall be used to keep heating the sludge digester up to 35 to 39 degree Celsius in sludge digester. The work shall include but not necessarily be limited to the following;

(1) Sludge Inlet valves.
(2) Digested sludge outlet telescope valves
(3) A:Gas mixing pipe line and its blowers or B: Mechanical mixer system.
(4) Gas pipe line to gas Bell and Gas engine.
(5) Sludge heat exchanger
(6) Scum breaker.
(7) Manholes.
(8) Water sprinkler.
(9) Observation windows.
(10) Flame arrester and trapping assembly.
(11) Pressure relief valve with flame arrestor..
(12) Pressure & vacuum control valves.
(13) Gas filters.
(14) Gas compressors.
(15) Mist separators.
(16) Water trap.
(17) Desulfurization equipment
(18) Hot water boiler unit (boiler, gas blower, fuel supply equipment).
(19) Biogas flare.
(20) Pressure gauges.

(21) Digested sludge out let flow meter.
(22) Gate Valves.
(23) Hot water circulation pumps.
(24) Sludge circulation pumps
(25) Sampling pumps

a. The TWL in the digester shall be 2.0 m below the ring beam as a free board. Hopper bottom capacity is not be considered in effective capacity. Bottom hopper shall have slope of 1 vertical to 4 horizontal. Inner opening size of digestion at top of digestion tank shall be at least 2.0 m dia.

b. Each digester tank shall be provided with Ductile Iron and Cast Iron piping specials, equipment etc., as per requirement of design. D.I. sludge feeder main with sluice valves to individual digester to feed the digester from the top of digester, from the raw sludge pump house shall be provided. Suitable valves control etc shall be provided for controlling the flow to individual digester.

c.

d. Digestion gas (bio gas) is highly flammable and explosive under normal atmosphere condition, all kind of safety valves such as flame arrester and trapping, other safety devices shall be provided at proper locations to avoid any accident cause of Bio gas leakage or catch fire.

e.

f. To supply these Gas safety devices and equipment, Contractor shall submit these manufacturers list and experience record to client to obtain the approval in advance. These manufactures must have ISO 9000 certificate to show client quality guarantee.

g.

h. Sludge withdrawal D.I. pipelines shall be minimum of 300 mm diameter. The pipeline shall be provided with necessary valves and fittings as required. The pipeline shall start from the center of the hopper portion. It shall be connected with RCC overflow chamber provided outside and below ring beam level through a telescopic arrangement.

i.

j. Down take pipe of minimum 300 mm dia meter from this chamber shall join the main header line feeding the sludge storage tank. The main header carrying digested sludge to the sludge storage tank shall be of D.I and having minimum of 300mm diameter with suitable valves. One sluice valve with 'Y' shape tee connection having blank flanges shall also be provided in the sludge withdrawal pipelines for each digester for back pressure application / rodding for opening of chokage etc. The RCC

overflow chamber as mentioned above shall have a partition wall, one portion shall be used for sludge withdrawal and second portion for supernatant withdrawal. Necessary bends, valves, fittings etc., shall be provided.

k.

l. Supernatant withdrawal D.I. pipelines having minimum of 250 mm diameter with ring for adjusting the levels shall terminate into the overflow chamber below the ring beam of the digesters. From this chamber another down take pipe of minimum 300 mm diameter shall be connected to a common header which leads the supernatant to the upstream distribution chamber of the primary clarifiers. Necessary bends/ specials and valves shall be provided.

m.

n. In case of emergency, the quantity of supernatant withdrawn from the digesters shall be admitted into the distribution chamber ahead of primary clarifiers by gravity. The supernatant withdrawal shall be done simultaneously with sludge pumping in digesters.

o.

p. C.I. gas line of minimum 150 mm diameter with a pressure gauge on the top of digester shall be provided with gas tight/gas leak proof valves of standard make (as per details of E & M specifications). It shall be connected to a common header of minimum 150 mm diameter leading to the gas holder. The C.I. pipelines shall be provided with drip traps at suitable elevation. The drip traps shall be housed in chambers and shall be provided with suitable disposal arrangements to the nearest drain.

q.

r. Each digester shall be provided with four leak proof inspection manholes having C.I. covers and observation window of 0.6 m x 0.6 m minimum size suitably located on the dome and those shall be leak proof.

s.

t. Two manholes openings of 1.2 m diameter each shall be provided in the vertical wall just above the formation level. It shall be provided with C.I puddle pipe and C.I blank flanges.

u.

v. RCC platform of size 1.5 m x 1.5 m shall be provided at ring beam level, acting as a loading/unloading bay for the machinery. Provision shall also be made for railing around the platform as required. Cat ladders shall be provided to reach upto the platform.

w.

x. Necessary brick masonry chambers shall be provided for valves on all types of pipeline at the ground level. Chambers shall have precast RCC removable slabs and CI. Steps for going down.

y.

z. All the pipelines from each digester shall be provided with valves so as to isolate it for withdraw or feeding of sludge or gas / supernatant flow etc. as and when required/ desired.

aa.

bb. D.I. sampling pipes of suitable diameter along with valves and fittings shall be provided in the vertical wall near T.W.L., middle and bottom with a common header to facilitate the independent withdrawal of sample at each level.

cc.

dd. The digesters shall work as constant level tanks. Whenever fresh sludge is added, equal quantity of supernatant and sludge shall over flow.

ee.

ff. Digesters shall be tested both hydraulically as well as pneumatically with compressed air to withstand a pressure of 250 mm water gauge to ensure no leakage of gas. The parameters and description given above pertains to single stage digestion. If the collaborator's design necessitates two stage digestions the same shall be provided.

gg.

hh. In either case, the responsibility shall be that of the contractor/ collaborator to provide a safe design to meet the standards required and percentage of solids concentration as specified for application on sludge drying beds.

ii.

jj. Permission from directorate (explosives) and Pollution Control Boards for construction of digesters shall be obtained by the contractor and any charges/ modifications required shall be at contractor's cost.

kk.

ll. A common RCC open steps staircase 1.2 m wide shall be provided for two digesters with necessary Loadings and connecting RCC platform at ring beam level to have access to both the digesters. Arrangements shall also be made from the ring beam to go upto the apex of the digesters. Tentative location of digesters is shown in the respective Layout plans for each STP.

mm.

nn. Gas Holder (Single Stage Bell)

oo.

pp. A common RCC open steps staircase 1.2 m wide shall be provided for the Gas Holding tank with necessary Loadings and connecting RCC platform at ring beam level.. Arrangements shall also be made from the ring beam to go upto the apex of the Gas holding Tank.

qq.

rr. Gas holder shall be Gas bell type installed on secondary sludge digestion tank or a separated dry gas holder. The capacity shall be minimum 4.5 hrs against daily generated Bio gas amount.

ss.

tt. Digestion gas (bio gas) is highly flammable and explosive under normal atmosphere condition, all kind of safety valves such as flame arrester and trapping, other safety devices shall be provided at proper locations to avoid any accident cause of Bio gas leakage or catch fire.

uu.

vv. Volume of Gas Bell is calculated form the TWL in the RCC tank when the gas holder is in raised position to the springing level of Bell.

(a) In calculating the effective capacity the volume of dome portion of Bell shall not be considered. Each gas holder shall consist of the following:-

i. A circular RCC tank of adequate diameter and height shall be provided with RCC floor partly below ground level.

ii. In raised position of steel Bell the top water level (TWL) in RCC tank shall be 500 mm above the bottom of the Bell.

iii. A free board of 500mm above TWL in RCC tank shall be provided. The RCC tank shall have a walkway all around the tank and a balcony of 1.5 m x 1.5 m with a staircase. A steel bell of circular cylindrical shape for gas storage shall be provided.

(b) The Gas Bell or the separated dry gas holder work shall include but not necessarily be limited to the following;

(c)

(d) (1) Gas inlet and an outlet piping and valves.

(e) (2) Emergency shut off valves with bypass line.

(f) (3) Pressure & vacuum control valves.

(g) (4) Pressure relief valves with flame arrestor.

(h) (5) Flame arrester and trapping assembly.

(i) (6) Pressure relief valves.

(7) Gas level gauges.

(8) Pressure meter.

(9) Maintenance manholes.

(10) Drain.

To supply these Gas safety devices and equipment, Contactor shall submit these manufacture list and experience record to client to obtain the approval in

advance. These manufactures must have ISO 9000 certificate to show client quality guarantee.

There shall be a C.I gas header coming from digesters to feed the gas holder tank. Provision shall be made by connecting gas holder outlet pipelines to the Bio-gas cleaning equipment, Engine and burner(s).

Connection from outlet shall also be made to compressor to compress gas. The compressed gas shall be supplied to different digesters through main/branch pipelines for mixing of digester content. Adequate number of valves shall be provided as required for control.

Outlet from the gas holders shall have adequate diameter to serve the above requirement.

All the control valves provided for gas holder shall be housed inside chambers at suitable elevation from formation level.

Drip traps shall be provided at suitable elevation on gas lines entering into and coming out from gas holder with suitable disposal arrangement to the nearest drain.

The gas holder shall be provided with RCC or SUS 316. Open stepped staircase to have access from the formation level up to the top of the gas holder. At the top of the tanks, platforms and balcony with G.I. pipe hand railing and C.I. vertical posts one meter high, suitably spaced along the periphery of the tank shall be provided.

The contractor shall make necessary arrangement for filling the RCC. tank for Gas Bell.

The gas holder shall also be provided with PVC sheet fixed on one of the guide girders of the gas holder. The PVC sheet shall have graduations marked to indicate the level of gas holder. An alarm system shall also be provided.

An over flow pipe in the RCC tank at suitable elevation having adequate diameter shall be provided and connected to the nearest drain for disposal.
Permission from Directorate (Explosives) and Pollution Control Board for constructing of gas holder shall be obtained by the contractor. Modifications/ arrangement as suggested shall be made at contractor's cost.

Gas flow meter of reputed make as approved by the client for measuring gas shall be provided and installed n the digester control room.

Bio-Gas Cleaning Equipment and Peripheral Equipment

Generated 100% of the raw Bio-Gas shall cleaned by the Desulfurization equipment (H_2S Scrubbing) to meet gas component for Gas Hot Water Boiler so that maintenance cost shall be reduced as well as it ran for a long life operation.

Cleaned bio gas shall send to Hot water boiler or flare with the Gas compressor.

The work shall include but not necessarily be limited to the following;
Gas supply line and valves.
Desulfurization equipment.
Flame arrester and trapping.
Pressure relief valves with flame arrestor.
Moisture trap.
Gas filter
Gas compressors
Drain

To supply all equipment and devices, Contractor shall submit all related technical information such as calculation sheet, gas component analyses and evidence at inlet an outlet at the equipment to obtain client approval in advance.

Contactor shall provide all necessary equipment and low cost operation system to meet Gas Engine.

Desulfurization equipment

Highly concentrated H_2S chemical substance shall be removed to proper level by sodium hydroxide tower or catalytic action or biological method to protect loss boiler efficiency and its break-down.
100% of duty and 100% of standby shall be provided.

Peripheral Equipment and devices for Bio-Gas application

Flame Arrest and Trapping assembly

The flame arrestor shall reduce flame power or temperature by metal mesh, and flame trapping is like spring flap door fixed by fuse, which the door shall be instantly closed when its melt by flame to protect fire. Contractor shall provide the assembled the flame arrestor and trap valves on the Bio gas line and its equipment to prevent any accident.

The flame arrestor and trap assembled valve shall be of suitable size for biogas applicable. It shall be used from primarily sludge digestion to Bio gas engine in pipelines, digestors Gas holder to prevent flash back during explosions. This device shall be installed in horizontal or vertical pipeline and hence it should be bi-directional.

The flame arrestor and trapping assembled valves shall be designed such that it results in minimal pressure loss under normal operating condition but ensure maximum safety in the event of explosion the end connection shall be flanged.
It shall be constructed of suitable materials of construction.

Pressure relief valves

The pressure relief valves shall be of suitable size for biogas applicable. It shall be used from primarily sludge digesion to Bio gas engine in pipelines to keep controling the gas pressure constantly to prevent any unsual presure condition in the pipe line and digestor. This device shall be installed in vertical installed.
It shall be constructed of suitable materials of construction.

Gas filters

The Gas filters shall be of suitable size and mesh for biogas applicable. It shall be used Bio gas engine and gas mixing compressor in pipelines to supply dirt free biogas to protect engins and gas compressors agenst loss engine efficiency and its break-down.
This device shall be installed in vertical installation.
It shall be constructed of suitable materials of construction.

Emergency shut-off valves with bypass line.

The emergency shut-off valves shall be of suitable size and closed automaticaly when receive signal of amonomal heat temprature and gas presure, which activated by CO_2 compressed power cylinder mounted direct on the valve.
It shall be used Bio gas hoder at inlet and outlet in pipline, and at the same moment, a bypass gas pipeline shall provide for maintenace work.
The valves shall be installed in vertical installation.
It shall be constructed of suitable materials of construction.

Moisture Trap

The moisture traps shall be designed and be suitable size to effectively separate out moisture in the biogas to gas cleaning equipment and biogas engin such that moisture

free biogas is made available at the outlet of a trap. It shall be constructed of suitable materials of construction. It shall be provided with suitable drain connection.

Water Trap

The water traps shall be designed and be suitable size to effectively separate out water in the biogas in pipeline such that water free biogas is made available at the outlet of a trap.
It shall be constructed of suitable materials of construction. It shall be provided with suitable drain connection.

Gas Compressors

Design Requirement

Compressor shall be provided for necessary capacity and rating as required and shall be of positive rotary or reciprocating type, water cooled, single stage oil free gas compressors. The cylinder shall be cast such that gas and water passage shall be separated by metallic wall and shall not have any gasket separating the two.

The gas compressors shall be designed and works tested complete with compressor unit, motor, base plate, water cooling system, gas and water pipework, valves, water separators, and all regulating and control equipment as required to provide an adequate and efficient compressed high pressure gas supply.

The compressors shall have water seals.

The compressors shall be designed to compress wet and sludge gas comprising methane and CO2 with trace elements including H, N & H2S. The gas shall be assumed to be water saturated. All metal parts in contact with gas shall be of stainless steel (type CF8M or 316).

Gas compressor gearbox shall be suitable for continuous running and intermittent starting under maximum load with the resultant high torque and shock loads. The gearbox shall have a service factor of 2 (Minimum).

A pressure relief system shall be included to operate on shut off pressure of compressors. This shall consist of actuated bypass and main gas valves which shall operate to dissipate the high pressure in the delivery main to the low pressure digestion tank.

A temperature sensor shall be installed to give a warning alarm and shut down facility in the event of the pressure relief valve operating.

Mode of Operation

The compressor shall operate on a duty / duty assist basis.

Manual control via start / stop pushbuttons at the control panel with auto switch off in case of temperature bypass or over pressure switch operating.

The compressors are to run on either a timed or continuous control selected by a two position selector switch mounted on the control panel.

When 'continuous' is selected, the compressor is to run continuously. Where 'timed' is selected the compressor is to run for fixed duration and to be off for fixed duration. The timed cycle shall be controlled by two adjustable timers (0-60 min) provided for each compressor.

Compressor is to trip and lock out due to the following but the work shall include but not necessarily be limited : (reset shall be manual)
Electrical overload
Earth fault
Motor over-temperature, monitored by thermistors in each phase
Over-temperature in the compressor gas delivery pipeline
Cooling water over-temperature
Rise in discharge pressure
Vacuum in suction line

Motors

Motors shall be squirrel cage type conforming to IS 325. The power rating shall be at least 125% of maximum power requirement. The other features of motors shall be as follows :

Type of duty : Continuous (Sl)
Method of starting : Star-Delta
Class of insulation : F (Temperature rise limited to class B)
Type of enclosure : TEFC and Flame proof
Degree of protection : IP 55

Digester heating system

Hot Water Boiler

CODES AND STANDARDS

The design, materials, construction, manufacture, inspection, testing and performance of boilers and accessories shall comply with all currently applicable statutes, regulations and safety codes in the locality where the equipment is to be installed. The equipment shall also conform to the latest applicable Indian or equivalent standards. Other international standards are also acceptable, if these are established to be equal, or superior to the listed standards. Nothing in this specification shall be construed to relieve the CONTRACTOR of this responsibility.

The materials, design, construction and testing of the boilers and accessories shall be in conformity with the applicable sections of the latest edition of the Indian Boiler Regulations (if applicable) and all amendments thereof. It shall be the CONTRACTOR'S responsibility to satisfy the Indian Boiler Authorities that all the stipulations of these regulations have been met, before fabrication of the boilers and accessories is started.

CONSTRUCTION FEATURES

The hot water boiler shall be flue tube vacuum evaporate type
–

Boiler Supporting Base

The complete boiler including all auxiliaries and accessories shall be shop assembled and shall be supported on a welded steel structural base, which shall form a part of the unit and require only a flat reinforced concrete slab foundation. Suitable lifting lugs shall be provided on the unit to facilitate handling. Foundation bolts for fixing the steel structural base on to the foundations shall also be supplied.

Platforms and Ladders

The boiler shall be provided with suitable platforms and ladders for gaining access to boiler top for operation and maintenance of valves, for reaching instruments and manholes etc. Platforms and ladders shall be provided with suitable hand railings.

Piping, Valves, Specialities and Instruments

All necessary piping, valves, specialties and instruments shall be in line with enclosed Piping and Instrumentation (P&I) diagram, piping material specifications and as

required for safe, reliable and satisfactory operation and proper maintenance of the boiler. Layout of integral piping for boilers shall ensure that all valves, instruments and specialties are located at maximum 1.5 M height as to be conveniently accessible for operation and maintenance.

Boiler Controls-Oil/Gas Firing

Combustion Control

The combustion system shall be fully automatic, either modulating type or HIGH/LOW/OFF firing type, with a minimum turndown ratio of 4:1. In either type of control, the boiler shall be ON/OFF control, below 25% of the boiler load. The fuel input to the furnace shall be regulated from boiler hot water outlet temperature using temperature controller or temperature switches and Forced Draft (FD) fan discharge damper or burner register damper which shall also be simultaneously regulated directly from fuel oil/gas control valve position so as to maintain correct air fuel ratio. Provision shall be made for locking the control at base load. A bypass selector switch shall be provided for manual control in emergency. The combustion control system shall be furnished complete with all actuating and operating devices, necessary control and bypass switches, relays, timers, solenoids and other control hardware.

Boiler Feed Water Control

Feed water supply to the boiler shell shall be automatically controlled to maintain flow at all loads.

Expansion Vessel

For closed circuit hot water system or where the system is pressurised, an expansion vessel shall be provided which shall act as system surge suppresser and main venting point of the system. The expansion vessel shall be installed at the highest point in the system and connected to the suction side of the pumps. The vessel shall be fitted with a sight glass to cover the full operating range and level switches for alarm and interlock for high and low levels. If the system requires to be kept pressurised from NPSH consideration of boiler feed water pumps, nitrogen under pressure shall be supplied to the expansion vessel through control valves to maintain the desired pressure. Safety relief valves shall be provided on the expansion vessel to prevent against nitrogen pressure increase above the maximum operating pressure, due to any malfunctioning of the system.

A mixing tank shall be provided as per process requirement.

Boiler Safety System

To protect the boiler from possible damage due to unsafe boiler operating conditions, the fuel feed to the burner shall be instantly cut-off on

occurrence of such unsafe operating conditions. The following conditions are considered unsafe for boiler operation:

(a) Burner flame failure

(b) Fuel oil/gas pressure low

(c) Fuel oil/gas temperature low

(d) Feed water supply failure

(e) Hot water temperature high

(f) Failure of FD fan/motor

(g) Water level low in expansion vessel

For proving the burner flame, burner windbox shall be provided with a suitably located, reliable and fool-proof flame sensor of photo-resistance type.

The boiler safety system shall be complete with all sensing devices such as flame sensor, pressure switches, temperature switches, level switches, all relays, timers, auxiliary switches and other hardware etc.

An alarm shall also be provided to alert the operator on occurrence of burner lockout. Also, indicating lamps to indicate each of the above causes of burner lockout shall be provided on the boiler control panel. A push button on boiler control panel for manually shutting off the boiler in emergency shall also be provided.

For gas firing, dual automatic safety shut off valves in main burner gas line with vent valve on the line between the shut-off valves shall be provided. The discharge of vent valve shall be piped to an area outdoors to a height above building roof where the gas may be safely dispersed.

Programming Control

A programming control system shall be provided for safe and automatic starting, stopping and emergency shut-down of the boiler. The programming control system shall on start-up, initiate FD fan, purge the furnace and gas passes for a set period prior to the initiation of burner lighting up, initiate lighting up only if all the pre-conditions such as fuel oil pressure "normal" and fuel oil temperature "normal" are satisfied, initiate lighting up of the pilot torch if adequate gas pressure exists, automatically lightup the pilot torch and then light-up the main burner. The system shall automatically shut down the boiler on the occurrence of unsafe operating conditions as described above. The system provided shall be complete with necessary hardware.

Boiler Control Panel

The control gear and starting gear for all auxiliaries shall be furnished by the CONTRACTOR and shall be centrally located on a control panel on the steel structural base. In addition, indicating lamps for indicating availability of supply, voltage, indicating operating conditions of each auxiliaries, indicating burner lockout causes shall also be provided on the boiler control panel. The panel shall

be factory piped and wired and completely enclosed with access door for maintenance. Motor starters shall be direct-on-line type.

PAINTING

Two coats of primer shall be applied to all steel and iron surfaces. In addition finish paint shall be applied to exposed surfaces, as required, to prevent corrosion.

Digestion sludge Heat Exchanger

Concentrated sludge from thickener in digestion tank shall be warm up by hot water supplied from the Heat recovery equipment. At the same time, the sludge in the digestion tank shall be fed to the heat exchanger by the sludge circulation pumps. All components of the Heat Exchanger that come in contact with the sludge shall be of stainless steel (SS304) construction.

The work shall include but not necessarily be limited to the following;

Hot water sludge heat exchanger.
Sludge and hot water circulation pumps
(3) Sludge temperature monitoring system.
(4) Safety valve and Devices.

Digester Mixing Equipment

A: Gas Mixing and Scum Breaker Equipment

Direct gas insert pipes shall be installed at top of digestion tank Digestion tank to mixing sludge effectively.

The mixing of digester contents shall be done by injecting compressed gas drawn from the gas holder. The gas flow shall be 0.135 Nm^3/m^3 Digester/hr.

The mixing gas shall be supplied from Gas bell pipe line through gas compressors.

Scum breaker and antifoaming water sprinkling shall provide to eliminate forming scum layer on the surface of sludge digestion tank or scum will be loss digestion system as well as it may be to creative obstruction of gas pipeline.

The work shall include but not necessarily be limited to the following;

(1) Gas supply line and valves.
(2) Pressure relief valves with flame arrestor.
(3) Flame arrester and trapping assembly.
(4) Gas filter.
(5) Water trap.
(6) Gas flow meter
(7) Pressure meter.
(8) Pressure switch for gas – low/high pressure indication
(9) Mist separators
(10) Gas compressors.
(11) Water sprinkler
(12) Scum breaker

B: Mechanical mixer

Digester mechanical mixer shall be vertical screw mixer with draft tube type or dry pit horizontal inline screw mixer with draft tube and mixing pipes.

Screw mixer shall consist of screw with shaft, speed reducer, and motor, and shall be normal and reverse rotation.

Mixing number of times in digester shall be not less than ten times per day.

The mixer shall have a self-cleaning screw optimised for effective mixing and vibration-free running.

The mixer shall be driven by a high effective 3 phase explosion protection motor. Motor shaft and rotor shall be dynamically balanced.

The vertical type mixer shall be provided the suitable mounting and sealing device for floor mounting.

All wetted materials shall be constructed from stainless steel SS304 grade.

Electrical equipment

The work shall include but not necessarily be limited to the following;

(1) Control and power part (control system)
(2) Circuit breaker
(3) Power switches and measuring units
(4) Modular control system
(5) Power part (circuit breaker, power switches)

Room for Boiler

Boiler shall be coupled and mounted on steel base frame.

Gas leakage detectors shall provide in the Boiler room along with alarm annunciation.

Requirement for Boiler room floor:
Dust free concrete or pavement

Ventilation of Boilerroom:
Boiler room should be well ventilated by forced ventilators with minimum three time per hour air change rate.

Minimal air change quantity technically required corresponds to the heat lost from cogeneration unit and inlet air to be burned by boiler.

Other safety requirements for air change shall be solved according to locally valid safety rules and standards to the satisfaction of Engineer.

Oil tank shall be located on the cantilever on the wall in the boiler room.

The electrical switchboard with base frame shall be located in adjacent to boiler.

Venting (degassing)
Piping above the roof with min. distance 3 m from possible source of the fire

Exhaust piping

(1) Independent exhaust piping of appropriate sizing leaded over boiler room.
(2) Piping shall be made of stainless steel SS 304.
(3) Leaded into chimney – overpressure system required.

Installation space

(1) Minimal free space from unit base frame on side of the unit 2000 mm (for both side).
(2) Minimal free space in front of electrical switchboard 1500 mm.
(3) Minimal free space from side where piping connection 1500 mm.

- Flare

The flare unit shall be designed for biogas flow generated during average flow conditions. It shall be fabricated of suitable materials (carbon steel with epoxy coating except for top portion which shall be in SS316 including the wind shield). The design of flare unit will be such that it shall be conveniently mounted on the steel supporting structure.

The Modular Flare structure consisting of 10 meters (minimum) Height with MS epoxy coated structural members, ladder with safeguard, Platform with railing, mounting arrangement for burner piping, and control panel and riser pipe with necessary isolation valves and check valve.

The velocity of biogas through the flare unit should be minimal keeping in mind 100-150 mm Water column pressure of biogas at flare inlet. The design of flare unit should allow maximum possible turndown ratio.

The flare work shall include but not necessarily be limited to the following;
- Electric ignition(Automatic) and flame control equipment
- Gas burners
- Flame arrester and trapping.
- Water Trap.
- Gas Flow meter.
- Gas compressor
- Lightning protection.

A suitable spark ignition system should be provided at a convenient location. Biogas / LPG shall be used as a pilot fuel. The pilot flame generated with the help of spark ignition systems shall propagated through the flare unit to ignite main biogas. The control system involving control panel, ignition transformer, etc. shall be provided for the said purpose. Control panel shall have audio-visual alarms for flow monitoring and push button ignition system.

H.T. cable shall be provided from the secondary terminal of ignition transformer upto spark ignition system. Necessary ignition electrode shall also be provided.

Adequate number of gas burners (minimum 2 Nos.) shall be provided to burn the biogas with 100% standby. Fencing shall be provided for gas burner area.

The Gas pipe connecting the Flare to the Gas plant must contain the following devices: an isolation device operated manually, an emergency shutdown device which interrupts the biogas feed automatically, a flame trap as a safety device.

Chlorination System

Chlorine solution diffusers shall be supplied and installed at the dosing point.

Treated sewage shall be dosed with chlorine gas at concentrations not more than 10 mg/l. Effluent from the chlorine contact tank shall not have more than 1 mg/l of residual chlorine.

Chlorinators

Vacuum type chlorinators shall be supplied with one duty and one standby unit.

Chlorinators shall be free-standing, floor-mounted, and shall have a turn down ratio of 10: 1 over the full range of works operation.

Each chlorinator shall be equipped with a motorized plug positioned to be actuated by a sewage flow at the works outlet.

The dosing rate shall be manually set and each chlorinator shall be equipped with a 0 to 10 mg/l scale and a manual dose setter over the complete range.

Mal-operation of the duty chlorination system shall be indicated in the chlorination room and the central MMI. The change to the standby system shall be carried out automatically in the event of a duty chlorinator failure.

A: Motive water pumps and Injector

Motive water pumps (1 working + 1 standby) shall be installed.

The pumps shall draw their supply from bore well/plant water supply.

The pumps shall be installed outside the chlorination room and shall be made from material resistant to corrosion by chlorine.

Two injectors shall be provided, each serving a duty / standby pair of chlorinators. The injectors shall be located near point of dosing i.e upstream of Chlorine contact tank.

B: Inline vacuum induction type chlorine injectors

(a) Inline vacuum induction type injector shall be designed for chemical induction and mixing for closed conduits and consist of induction unit, motor, lift rail, chemical hose assembly, stainless steel packing gland assembly and ball check valve.

(b) All wetted materials shall be constructed of Grade 2 Titanium (unalloyed). The motor shall be chemical duty type.

Chlorine

Chlorine shall be supplied as liquid from nominal 1 tonne chlorine tonner.

The Tonner Room

Storage shall be provided for chlorine tonners sufficient for at least one month's usage at normal rates of application.

The system shall be designed to prevent freezing of the liquid chlorine at the maximum rate of withdrawal.

Tonners on line, tonners on standby and full and empty tonners, shall be stored separately in the tonner room.

Four sets of tonner rollers shall be provided. Tonners not in use shall be stored on concrete cradles.

A 2-tonne overhead single girder electric travelling crane shall be provided in the chlorine tonner room for the following functions:

Offloading (and reloading) of tonner from trucks;
Handling of tonners within the storage area.

The system shall serve the tonner store width over the entire length including the loading/ unloading area.

The hoist and traverse speeds shall be as follows ;

Long traverse speed : 5m/min
Cross traverse speed : not more than 5m/min
Slow lifting speed : 1m/min
High lifting speed : 5m/min

The container lifting beam shall be specifically designed for handling chlorine containers and equipped with necessary shackles and hooks.

Operation of crane system shall be from the floor level using independent push button pendant controls operating at a 230 volt 50 Hz AC supply.

Two lifting beams shall be provided (a duty and a spare) and a one tonner weigher to be suspended from the crane hoist.

When the pressure in the duty chlorine tonner falls to less than 1 kg/cm^2 the automatic changeover device shall operate to isolate the empty tonner and to bring the full standby tonner on line.

A pit and alkali absorption system shall be provided to contain and neutralise chlorine in the event of a leak. The system shall comprise a pit located in the tonner storage room and accessible by the overhead crane system. The pit shall be surrounded with removable guard railing. The pit shall be kept full with a neutralising solution of lime. The pit shall be capable of holding side by side two chlorine tonners. A provision shall be made to drain the pit.

In addition to the above Automatic chlorine leak absorption system (Gas Scrubber with NaOH dosing) shall be provided adjacent to the Tonner room. The process shall be designed to contain and neutralize chlorine gas vapours in response to gas leak or catastrophic cylinder failure. The system should be able to absorb 99.99% of the chlorine gas entering the scrubber.

When a leak occurs, the pump and fan shall start automatically. The fan shall provide sufficient vacuum to contain the chlorine gas and deliver it to the scrubber. The pump shall circulate the concentrated caustic solution over the scrubber packing to absorb all the chlorine gas.

Special consideration shall be given to any floor drainage system in the tonner building; adequate traps shall be provided to ensure that chlorine gas cannot escape. All leader tubes carrying cables or pipes out of the building shall be sealed at either end to prevent any chlorine gas leaking out.

Chlorination Room

The chlorination room shall be constructed adjacent to the tonner room but with no interconnecting door or other form of access.

Gas lines from the tonner room into the chlorination room shall run in ducts to be sealed after installation and prior to commissioning.

Chlorine Leak Detectors

Not less than three chlorine gas leak detectors shall be provided each, with a single detector cell. At least two sensors shall be located in the chlorine tonner storage room and at least one sensor in the chlorination room. The chlorine leak detectors in the tonner room shall be mounted at each end of the tonner room.

The chlorine leak detectors shall have two adjustable alarm levels sensitive to chlorine concentrations above 1 mg/m3. The range of adjustment of alarm levels shall facilitate selection of the following alarms:

low level 2 mg/m^3
high level 4 mg/m^3

The low level alarm shall :

Initiate a local audible and visual alarm;
Start the ventilation fans in the tonner and chlorination rooms;
Raise an alarm at the local control panel and at the central MMI.

The high level alarm shall:

Initiate local audible and visual alarm;
Initiate audible and visual alarms outside the buildings (the alarm shall be sufficiently loud to be heard in all buildings at the STP);
Raise an alarm at the local control panel and at the central MMI;
Shut down the chlorination systems;
Stop the tonner room and chlorination room exhaust fans.

The chlorine detectors shall have self-checking circuitry and detector failure alarms shall be provided at the local control panel and central MMI.

Detector failure alarms shall not be combined with the leak alarms.

Statutory warning notices relating to the storage and handling of chlorine shall be provided. The signs shall be pictorial and provided in Kannada and English.

Ventilation System

Each area where chlorine is stored or used as gas or liquid shall be provided with a forced ventilation system.

Air intakes shall be sized to allow uniform ventilation and positioned to prevent possible recirculation.

Exhaust air shall be ducted from low level and discharged at high level.

An air change rate of four per hour under normal condition and a minimum of twenty changes of air per hour under shall be used in the event that a chlorine leak is detected.

Exhaust fans shall be heavy duty industrial pattern manufactured from chlorine resistant materials.

Ductwork shall be manufactured from U-PVC extruded sheets or circular sections.

Ducts shall be designed in accordance with relevant Indian standard specifications.

Fan controls shall be linked to the gas leak detection system.

Hardwired fan controls shall be provided and shall be manually controlled. An override shall be provided to operate the fans in the event of a chlorine leak alarm.

Fan controls shall be grouped in an enclosure outside the ventilated area and shall include the following:

fan off/on;
fan running/failed indication lights;
low and high gas leakage indication alarm light.

Chlorine Residual Monitors

Chlorine residual monitors shall be provided at the plant outlet.

The monitor installation shall be located in a covered location easily accessible for viewing and maintenance and shall be provided complete with sample pumps as necessary to ensure the continuity of the sample.

The sampling pipe work complete with isolation valves etc. shall be designed to ensure the sample reaches the monitor in a time not greater than 1 minute. The monitor drainage pipe work shall permit the visual checking of the presence of flow and shall discharge to the foul drain.

Sample sewage not passed through the monitor shall be returned to the process.

The residual signals shall be displayed at the local control panel.

High and low chlorine residual levels shall raise alarms at the local control panel.

Safety Equipment

Materials and equipment necessary to ensure the safety of personnel operating the chlorination plant and others shall be provided.

The equipment shall include:

Two sets of approved self contained breathing apparatus, each comprising an air set, carrying harness, face mask and valves and ancillary equipment. Each set shall be provided with three 1200 litre capacity, 140 mm diameter, air tonners;
Two sets of approved positive airline breathing apparatus, each comprising body harness, face masks and valves and 30 m of airline. One air trolley, comprising wheeled frame with two air tonners, control manifold, airline hose and hose winding drum. Two spare tonners suitable for changeover shall be provided ;

One portable electric motor driven air compressor for recharging air tonners, complete with quick-release air hose couplings;

Two `instant action' resuscitators.;

Four sets of safety clothing in various sizes, each comprising PVC overalls, wellington boots with steel toe caps, goggles, gloves and safety helmets.

Each set of safety equipment shall be mounted in a glass-fronted, non-locking PVC coated steel cabinet in approved locations on the outside of the building.

Two emergency showers shall be provided and shall be installed outside on either side of the tonner room.

Each shower shall be operated automatically by a quick acting hand or foot valve.

Four eyebaths shall be supplied. Two eyebaths shall be adjacent to each of the showers.

Water for the showers, etc, shall be drawn from the service water supply.

A telephone will be provided close by outside the building for emergencies.

Chlorination Power and Control

A combined MCC and control panel shall be provided and located in a suitable location protected from the weather and the effects of the process. The control panel shall provide facilities for :

Display status and values associated with the chlorination systems;
Duty pump selection;
Annunciate alarms associated with the chlorination systems;
Operator adjustment of process set points.

The chlorination systems shall operate using a fixed manually set dose rate. The quantity of chlorine dosed will therefore be adjusted in direct proportion to the process flow at the dosing point.
The chlorine residual monitors to be provided shall be used for monitoring and alarm purposes only.

Plant Drainage Pump set

The total head capacity curve shall be continuously rising towards the shutoff with the highest at shut off.

The pump shall run without undue noise and vibration.

The power rating of the pump motor shall not be less than the power required from zero discharge to zero head.

Pump shall be submersible type with double mechanical seals. Motor shall be of IP 68 protection.

It shall be suitable for handling turbid water. Pump and motor shall have common shaft.

Delivery pipe of drainage pump sets shall be of size 40 NB and as per IS 1239, heavy class. Required length of pipes and fittings shall be provided. Pumping main shall be common for two pumps.

Level switch to start and stop the pump automatically shall be supplied with the pump. A level indicator shall also be provided.

The capacity, total head and range of operating head of drainage pump set shall be as specified in particular mechanical requirements.

The material of construction of pumps shall be as follows :

S. No.	Component	Material
(i)	Impeller	Stainless Steel :ASTM743CF8M
(ii)	Casing	Cast Iron : IS 210 Gr. FG 200
(iii)	Shaft	Stainless Steel: BS:970 GR 410

6.30 Fire Extinguishers

(a) Portable fire extinguishers are to be provided for all units as per the requirement of Tariff Advisory Committee (TAC) or meeting the requirement of local regulations whichever is more stringent.

(b) All the extinguishers shall be of TAC approved.

6.31 Propeller Exhaust Fan

6.32

6.33 The fan should comply with IS 2312.

6.34

6.35 The blades shall be of mild steel and properly balanced so as to avoid noise and vibration.

6.36

6.37 The blade and blade carriers shall be securely fixed so that they do not loosen in operation. The means provided for securing the fan mounting or fan casing to the wall partition or window shall be such as to provide a secure fixing without damage to the fan or wall.

6.38

6.39 Suitably designed guards shall be fitted to the inlet and the outlet side to prevent accidental contact. No flammable material shall be used in the construction of fan. Moulded parts, if used, shall be of such materials as to withstand the maximum temperature attained in the adjacent component parts.

6.40

6.41 The fan shall have protective insulation or be capable of being earthed. A fan with protective insulation may be of all insulated construction or have either double insulation or reinforced insulation. Each fan should be provided with a 10 sq.mm mesh bird screen. The sheet used for the cowl should be 14 G.

6.42

6.43 Air-conditioning Equipment

6.44

6.45 The air conditioning units shall be of split type, with the outdoor condensing unit mounted on the terrace of the room or grouted on external side of the wall with suitable brackets.

6.46

6.47 Valves

6.48

6.49 Valves shall be as per internationally recognized standards. Flanges shall be machined on faces and edges. Flanges shall conform to ISO 7005, IS 6392 ,BS EN 1092-1/ BS 4504.

6.50

6.51 Valves shall be double flanged type and the faces shall be parallel to each other. The flange face should be at right angles to the valve centreline. Back side of valve flanges shall be machined or spot faced for proper seating of the head and nut.

6.52

~~**6.53 Valves buried or installed in underground chamber, where access to a handwheel would be impractical, shall be operated by means of extension spindle and/or keys. Wherever extension spindle is provided, the valve shall also be provided with suitable headstock.**~~

~~**6.54**~~

~~**6.55 Valve of diameter 450 mm and above shall be provided with lifting eyes and shall have detachable bolted covers for inspection, cleaning and servicing.**~~

~~**6.56**~~

~~**6.57 Valve shall be suitable for frequent operation as well as operation after long periods of idleness in either open or closed position.**~~

~~**6.58**~~

~~**6.59 The valve stem, thrust washers, screws, nuts and all other components exposed to the water shall be of a corrosion resistant grade of stainless steel.**~~

~~**6.60**~~

~~**6.61 Valves shall be free from sharp projections which are likely to catch and hold stringy material.**~~

~~**6.62**~~

~~**6.63 All the valve shall be of 10 bar rating.**~~

~~**6.64**~~

~~**6.65 All the valves on the suction and delivery side of the Terminal sewage pumping station shall be of Knife gate type.**~~

~~**6.66**~~

~~**6.67 All the valves on the suction and delivery side of the Return activated sludge pumping station shall be of Knife gate type.**~~

~~**6.68**~~

~~**6.69 All the valves provided at the delivery side of the Terminal pumping station shall be motor operated.**~~

~~**6.70**~~

~~**6.71 2 sets of ladders shall be provided in the raw sewage pumping station to facilitate access of valves.**~~

~~**6.72**~~

3.18 Valves

3.18.1 Electric Actuator

(a) All local controls shall be protected by a lockable cover.

(b) Each actuator shall be adequately sized to suit the application and be continuously rated to suit the modulating control required. The gearbox shall be oil or grease filled, and capable of installation in any position. All

operating spindles, gears and head stocks shall be provided with adequate points for lubrication.

(c) The valve actuator shall be capable of producing not less than 1½ times the required valve torque and shall be suitable for at least 15 minutes continuous operation.

(d) The actuator starters shall be integrally housed with the actuator in robustly constructed and totally enclosed weatherproof housing. The motor starter shall be capable of starting the motor under the most severe conditions.

(e) The starter housing shall be fitted with contacts and terminals for power supply, remote control and remote positional indication.

(f) Each starter shall be equipped as follows :
  (1) 2 No. Three phase magnetically operated line contactors with no-volt release and electrical and mechanical interlock.
  (2) 1 No. Three phase thermal cut-out device.
  (3) 1 No. Control circuit transformer fully protected by fuses on primary and secondary circuits.
  (4) 1 No. Set of "Open", "Close" and "Stop" buttons.
  (5) 1 No. Local- Off-Remote switches with padlocking facilities.
  (6) 1 No. Set of torque and limit switches for "Open" and "Close" positions.
  (7) 3 No. Sets of auxiliary limit switches in each direction.
  (8) Valve position indicator and hand wheel for manual operation.
  (9) Reduction gear unit

3.18.2 Sluice Valves

(a) Sluice valve shall generally confirm to IS 14846.

(b) Sluice valves shall be of non-rising spindle type. The valve shall be furnished with a bushing arrangement for replacement of packing without leakage. Shoe and channel arrangement shall be limited to valves of 400 mm and above. The gap between the shoe and channel shall be limited to 1.5 mm.

(c) Valves of 400mm and above shall be provided with thrust bearing arrangement for ease of operation.

(d) Valves of diameter 400 mm and above shall be provided with enclosed gear arrangement for ease of operation. The operation gear of all valves shall be such that they can be opened and closed by one man against an unbalanced head 15% in excess of the maximum specified rating. Valve and any gearing shall be such as to permit manual operation in a reasonable time and not exceed a required rim pull of 400 N.

(e) All valves, spindles and hand wheels shall be positioned to give good access for operational personnel.

(f) All the hand wheels shall be arranged to turn in a clockwise direction to close the valve. The direction of rotation for opening and closing of the valve shall be indicated on the hand wheels.

(g) The material of construction of valve shall be as follows :

S. No.	Component	Material
(i)	Body and Doors	Cast Iron : IS:210 Gr FG 220
(ii)	Spindle	Stainless Steel: BS:970 Gr 431
(iii)	Seat Rings	Stainless Steel: BS:970 Gr 304
(iv)	Back seat bush	Bronze : IS:318 Gr LTB2
(v)	Shoe and channel linings	Stainless Steel : BS:970 Gr 304
(vi)	Internal Fasteners	SS 316

3.18.3 Knife Gate Valves

(a) The valve shall meet requirements of MSS SP 81.

(b) Outer body shall be provided with inner liner in corrosion resistant Stainless Steel which shall extend into the gland. The body shall be devoid of any wedge / dead pockets to avoid settling of suspended particles and solids in the service fluid.

(c) The gate/plate shall be precision buffed and the edge contoured to a knife edge. The gate shall move along / be guided by the seat ring to ensure that it scrapes any deposit / scale, enabling smooth uninterrupted movement.

(d) Seat shall be so designed that there is no recess / relieved groove to harbor deposition that could build-up and swamp the valve. The design to also incorporate bosses that guide the gate and avoid deflection, ensuring positive shut-off.

(e) The stem shall have double start threads cut in order to ensure smooth and speedy operation.

(f) Gland packing shall offer minimal frictional resistance and precludes external lubrication. As positive sealing element, the packing shall also include a resilient rubber ring.

(g) The knife edge and seat face in flow path shall be hard faced to a hardness of 400 to 450 BHN to counter erosion. In such cases, provision shall also be made to ensure the fluid contact with the seat ring is minimal.

(h) The material of construction of valve shall be as follows :

S. No.	Component	Material
(i)	Body	Cast Iron : IS:210 Gr FG 260
(ii)	Inner lining	Stainless Steel: BS:970 Gr 304
(iii)	Knife gate / plate	Stainless Steel: BS:970 Gr 304
(iv)	Stem	Stainless Steel : BS:970 Gr 304
(v)	Seat ring / Boss	Stainless Steel : BS:970 Gr 304
(vi)	Gland housing	Cast Iron : IS:210 Gr FG 260
(vii)	Gland packing	Teflon impregnated with the asbestos + rubber

3.18.4 Slide Gate Valve

(a) Valve shall be of wafer type with elastomer body sealing arrangement for bi-directional shut-off. The valves shall be designed to allow gland repacking without relieving line pressure.

(b) Body shall be two-piece cast construction bolted together with a mid-flange.

(c) The elastomer body seal shall be held in body such that it is kept away from direct impingement of any particles in the flow medium.

(d) The gate shall be provided with a beveled edge to facilitate positive closure of valve even with contaminated area.

(e) The body internals shall be countered such that settlement of particles in the media.

(f) Purge connection shall be provided optionally for these valves for cleaning the seating area.

(g) The material of construction of valve shall be as follows :

S. No.	Component	Material
(i)	Body	Cast Iron : IS:210 Gr FG 260
(ii)	Gate	Stainless Steel: BS:970 Gr 304
(iii)	Stem	Stainless Steel: BS:970 Gr 304
(iv)	Body seal	Stainless Steel : BS:970 Gr 304
(v)	Hand wheel	Cast Iron : IS:210 Gr FG 260

3.18.5 Non Return Valve

(a) The valves shall be suitable for mounting on horizontal pipe line.

(b) The internal parts shall be easily accessible for inspection through inspection hole.

(c) Hydraulic passages and doors shall be designed to avoid cavitation.

(d) Valves shall be of swing type or ball type. Ball valves must house a freely moving ball in such a way that return flow is effectively prevented.

(e) Valves shall be quick closing type with non-slam characteristics. In case of swing type, the non- slam characteristics shall be achieved by providing suitable combination of door and hydraulic passages without any external lever/damping arrangement.

(f) Valves 450 mm and above shall be provided with supporting foot.

(g) Swing door valves of size 600mm and above shall be of multidoor type.

(h) Direction of the flow shall be clearly embossed on the valve body.

(i) Maximum pressure drop across the valve shall be 0.4 mwc.

(j) Maximum allowable leakage rate shall be 7cc/hr/mm diameter.

(k) The material of construction of valve shall be as follows:

S. No	Component	Material
1.	Body and Door	Cast Iron : IS 210 Gr. FG 200

2.	Body and Door Ring	Stainless Steel : ASTM A743 CF8, BS970 Gr. 304 S11
3.	Hinge Pin	Stainless Steel : BS970 431 S29
4.	Bearings	Teflon

3.18.6 Telescopic Valves

The telescopic valve shall be a proprietary item of proven design manufactured in cast iron and adjustable to cater for variation in level.

The bell mouth height shall be controlled by a hand wheel operated from top of the chamber.

The bell mouth, pipe work, spindle and headstock shall be robustly constructed with adequate brackets of cast iron.

The bell mouth shall be connected by swept tees to a cast iron sludge outlet pipe of suitable diameter.

Component	Material
Bell Mouth	Cast Iron : IS:210 Gr. FG 200
Piping	Cast Iron : IS:210 Gr. FG 200
Spindle	Stainless Steel Gr. 304
Hand wheel	Cast Iron : IS:210 Gr. FG 200

3.18.7 Diaphragm Valves

Diaphragm valves shall be of the full-bore type to suit the maximum working pressure ratings required. Body ends shall be flanged and drilled to BS EN 1092-1/ BS 4504.

Indicators shall be supplied where specified showing both OPEN and CLOSED positions shall be supplied and provisions made for initiating the operation of remote indicator lights in the fully OPEN and CLOSED positions.

Valves used for toxic or hazardous fluids shall be provided with an additional `O' ring seal of nitrite rubber or other approved material.

Diaphragms shall be composed of moulded reinforced, flexible material attached by studs to the compressor. Diaphragm materials shall, where required, be composed of corrosion resistant material.

3.18.8 Isolating Cocks

For isolation of small bore pipework tapings for instrumentation equipment etc., and for individual component isolation, the cocks shall be stainless steel, 0.25 turn ball or plug valve with the operating handle arranged to indicate the open and closed positions. Where specified, means shall be provided for securing the valve body to a front panel or near surface.

3.18.9 Pressure / Vacuum relief valves

Pressure relief valves shall be capable of relieving pressure in the system to prevent the system being pressurised in excess of a preset maximum allowable pressure. The valves shall be drops tight under no flow conditions.

Vacuum relief valves shall be capable of preventing the vacuum pressure to be developed in the system by allowing air entry. The valves shall be drops tight under no flow conditions.

The valve operation shall be achieved by the interaction of the inlet pressure and an intermediate pressure produced by a pilot valve or relay system acting on the upper side of the main valve.

The pilot valve or relay system shall be actuated by a diaphragm connected to the inlet pressure on its underside and a constant pressure on its upper side derived either from weights or from a spring.

Body ends shall be flanged and drilled to BS EN 1092-1/BS 4504.

3.18.10 Adjustable Weir Plates

The adjustable weir plates shall be manufactured from 5mm thick FRP or GRP Plates and to the approval of the Employers Representative.

Weir plates shall be complete with fixing nuts, bolts and washers and suitable for a total vertical adjustment of 100 mm. Fixings shall be designed for ease of accurately levelling the plates, securing the plates, and shall enable the plates to be adjusted during the life of the Works to accommodate differential settlement of the structure

3.18.11 Eccentric Structure Valve

(a) Valve shall be eccentric structure or horseshoe type disc and body. The valve shall be used for sludge line and flow control.

(b) The valves shall be for a smooth flux of fluid and suitable for fluid contained sludge and impurities at the treatment plant.

(c) The material of construction of valve shall be as follows:

S. No.	Component	Material
(i)	Body	Cast Iron : IS:210 Gr FG 260 or ductile iron
(ii)	Disc	Ductile iron with rubber lining
(iii)	Stem	Stainless Steel: BS:970 Gr 304
(iv)	Hand wheel	Cast Iron : IS:210 Gr FG 260

6.73 ~~Domestic Water Pump sets~~

~~The Pump shall be of Centrifugal type, self priming and monoblock type, suitable for pumping the clear water. All the necessary piping with union, bends and tees shall be provided. Suction and discharge isolation valves and non-return valves on the discharge side shall be forged steel. Piping shall be as per IS: 1239 heavy class.~~

3.19 -Quality

A. Product of an experienced manufacturer.

1. Must demonstrate equal or larger capacity installations using similar equipment.

2. Equipment installed and successfully operating for at least 5 years having specified constructional features equal to or higher than the specified size and rating.

3. Provide names and phone numbers of contacts at referenced installations to verify performance.

4. Demonstrate to satisfaction of Engineer that equipment to be provided is equal to that specified.

3.20 Warranty

A. Comply with the requirements of each type of Equipment and specification mentioned elsewhere in this document.

B. Warrant all components to be free of defects in materials or workmanship for 12 months from date of satisfactory completion of performance test.

C. Individual warranties by component manufacturer in lieu of single source responsibility by the main Equipment manufacturer shall not be acceptable.

D. Items which fail during the warranty period, excluding expendable items, shall be replaced without cost to the Owner.

E. Provide manufacturer's guarantee and warranty certificates prior to equipment start-up.

3.21 —Pipelines, Pipe work and Fittings

3.21.1

——Applicable codes

The following codes and standards unless specified herein shall be referred to, or equivalent to the approval of Engineer.

3.21.2 Materials

IS 210 :	Specification for grey iron casting
IS 290 :	Specification for coal tar black paint
IS 456 :	Code of practice for plain and reinforced concrete
IS 458 :	Specification for pre cast concrete pipes (with and without reinforcement)
IS 516 :	Method of test for strength of concrete
IS 638 :	Specification for sheet rubber jointing and rubber insertion jointing
IS 783	Code of practice for laying of concrete pipes

:

IS 816 : Code of practice for use of metal arc welding for general construction in mild steel

IS 1367 : Technical supply conditions for threaded steel fasteners

IS 1387 : General requirements for the supply of metallurgical materials

IS 1500 : Method for Brinell hardness test for metallic materials

IS 1536 : Specification for centrifugally cast (spun) iron pressure pipes for water, gas and sewage

IS 1537 : Specification for vertically cast iron pressure pipes for water, gas and sewage

IS 1538 : Specification for cast iron fittings for pressure pipes for water, gas and sewage

IS 1916 : Specification for steel cylinder pipes with concrete lining and coating

IS 2078 : Method for tensile testing of grey cast iron

IS 3597 : Method of tests for concrete pipes

IS 3658 : Code of practice for liquid penetrant flow detection

IS 5382 : Specification for rubber sealing rings for gas mains, water mains and sewers

IS 5504 : Specification for spiral welded pipes

IS 6587 : Specification for spun hemp yarn

IS 7322 : Specification for specials for steel cylinder reinforced concrete pipes

3.21.3 Code of Practice

IS 783 : Code of practice for laying of concrete pipes

IS 3114 : Code of practice for laying of cast iron pipes

IS 3764 : Excavation work - Code of Safety

IS :	4127	Code of practice for laying of glazed stoneware pipes
IS :	5822	Code of practice for laying of electrically welded steel pipes for water supply.
IS :	6530	Code of practice for laying of asbestos cement pressure pipes.

3.21.4 Materials for Pipelines

Each pipeline shall be constructed in a material compatible with the fluid conveyed through that pipeline, i.e. the materials used in the pipes which are or can be in contact with the untreated or treated sewage, shall not contain any matter which could impart taste or odor or toxicity or otherwise be harmful to health or adversely affect the sewage conveyed. Nor shall any pipe be adversely affected by the fluid being conveyed through that pipe.

Pipe work and valve materials for the following duties shall be as follows or equivalent to the approval of the Engineer:

Table - 13.1 Pipe work and Valve Materials

Application / Location	Material
Chlorine:	
Drum connections	cadmium plated 70/30 copper nickel CN 107, BS 2871 : Part 1:
Chlorine gas or liquid	flanged or welded carbon steel, CAF flanged joints
Chlorine gas lines below atmospheric pressure	polyvinylidene fluoride (PVDF) with solvent welded or flanged joints/ Class E UPVC in concrete covered ducts outside building.
Chlorine solution	Inside building and in exposed areas, rubber lined carbon steel
Polyelectrolyte dosing line	Valves shall be globe type with forged steel bodies, monel spindles, stainless steel seats and PTFE gland packing or carbon steel, monel plug, PTFE sleeved plug UPVC/HDPE

Application / Location	Material
Alum	HDPE(High density polyethylene)
Water: Raw Sewage, Process sewage, dirty waste water, supernatant and treated Sewage/Effluent, Process sludge Digester Gas Service water	Mild steel with mortar lining/gunniting (Beyond 1000mm diameter of pipe) or ductile iron (Up to 1000mm). Cast Iron GI (below 80mm), ductile iron (80mm and above).
Air: Process Air	Mild steel Galvanised–, Stainless steel AISI 316 for exposed or buried service and PVC for submerged service.

3.21.5 Ductile Iron Pipes and Fittings

3.21.5.1 —Pipes and Fittings

(a) General

Ductile iron pressure pipes and fittings (Class K9) shall comply with IS 8329 and IS 9523. All fittings shall be socketed unless specified otherwise.

(b) Materials

The materials used in the manufacture pipes and fittings shall comply with IS 8329 and IS 9523.

(c) Tests

Tests on pipes and fittings shall be carried out in accordance with IS 8329 and IS 9523. The test method shall be submitted for approval of Engineer.

The Engineer shall be permitted free access to the place of manufacture for the purpose of examining, inspection and witnessing the testing of pipes and fittings.

3.21.5.2 —Joints

(a) Spigot and Socket Joints

These shall have sockets which are integral with the pipe and incorporate an elastomeric rubber ring gasket conforming to IS 12820.

(b) Flanged Joints

These shall comply with dimensions and drilling details shall be to BS EN 1092-1/BS: 4504 Table10/11 and16/11.All flanged joints between steel and ductile iron pipe work shall be electrically isolated joints. These shall have isolation gaskets between the flanges, isolation sleeves around all bolts and isolation washers under all bolt heads and nuts. All materials shall be supplied by a specialist manufacturer and be to the approval of the Engineer.

3.21.5.3 —Linings

Ductile iron pipes and fittings shall have a cement mortar lining, in accordance with IS 11906 or ISO 4179.

Pipe linings shall be inspected on site and any damage or defective areas made good to the satisfaction of the Engineer. The Contractor may use specialist mortars, mortar additives or curing agents only with the approval of the Engineer.

Certain sections are amplified as follows:

No additives shall be used without the written approval of the Engineer, and shall be used strictly in accordance with the manufacturer's recommendations.

The minimum thickness of the lining at one point shall not be less than 4 mm.

3.21.5.4 —Coating

(a) General

Ductile iron pipes and fittings shall be zinc coated with bitumen over coating, all in accordance with the following Specifications. Buried pipes and fittings shall also have a site or factory applied polythene sleeving. Pipe coatings shall be inspected on site and any damage or defective areas made good to the satisfaction of the Engineer.

(b) Zinc Coating

Zinc coating shall comply with ISO 8179 and shall be applied as a spray coating. The mass of sprayed metal shall not be less than 130 g/m^2 as described in Clause 5.2 of ISO 8179.

(c) Bitumen Coating

Bitumen coating shall be of normal thickness 0.07 mm unless otherwise specified. It shall be a cold applied compound complying with the requirements of BS 3416 Type II, suitable for tropical climates, factory applied in accordance with the manufacturer's instructions.

Damaged areas of coating shall be repainted on site after removing any remaining loose coating and wire brushing any rusted areas of pipe.

(d) Polythene Sleeving

Where polythene sleeving is specified (generally for all buried DI pipes) to be applied in addition to bitumen coating it shall comply with ISO 8180. Site applied sleeving shall be stored under cover, out of direct sunlight, and its exposure to sunlight shall be kept to a minimum. Pipes having a factory applied sleeving must be stored in the same conditions.

~~6.74 Reinforced Cement Concrete Pipes~~

~~6.74.1 Design~~

~~Design of RCC pipes including reinforcement details and the ends of pipes shall be in accordance with the relevant clauses of IS: 458.~~

~~Manufacturing~~

~~General~~

The method of manufacture shall be such that the form and the dimensions of the finished pipes are accurate within the limits specified in relevant clause of IS: 458. The surfaces and edges of the pipes shall be well defined and true, and their ends shall be square with the longitudinal axis. The ends of the pipes shall be further reinforced by an extra ring of reinforcement to avoid breakage during transportation.

The RCC pipes and collars/rubber rings shall be systematically checked for any manufacturing defects by experienced supervisors so as to maintain a high standard of quality.

The Engineer shall at all reasonable times have free access to the place where the pipes and collars/rubber rings are manufactured for the purpose of examining and testing the pipes and collars/ rubber rings and of witnessing the test and manufacturing.

All tests specified either in this Employer's Requirements or in the relevant Indian standards shall be performed by the supplier/contractor at his own cost and in presence of the Engineer if desired. For this, sufficient notice before testing of the pipes and fittings shall be given to the Engineer.

If the test is found unsatisfactory, the Engineer may reject any or all pipes of that lot. The decision of the Engineer in this matter shall be final and binding on Contractor and not subject to any arbitration or appeal.

- Materials

For all materials Factory's test result, and written guarantee document with necessary analysis data shall be submitted to obtain the approval of the Engineer before carrying to sites.

- Cement

Cement used for the manufacture of RCC pipes and collars shall conform to relevant IS codes. The use of pozzolana as an admixture to Portland cement shall not be permitted.

- Aggregates

Aggregates used for the manufacture of RCC pipes and collars shall conform to IS: 383. The maximum size of aggregate should not exceed one third the thickness of the pipe or 20mm, whichever is smaller.

- Mixing and Curing Water

Water shall be clean, colour less and free from objectionable quantities of organic matter, alkali, acid, salts, or other impurities that might reduce the strength, durability or other desirable qualities of concrete and mortar. Contractor shall submit water quality report before using it.

Reinforcement

Reinforcement used for the manufacture of the RCC pipes and collars shall be mild steel Grade I or medium tensile steel bars conforming to IS:432 (Part-1) or hard-drawn steel wire conforming to IS: 432 (part 2). Reinforcement cages for pipes and collars shall be as per relevant requirement of IS:458.

Concrete

Concrete used for the manufacture of RCC pipes and collars shall conform to IS: 456. The minimum cement content and minimum compressive strength of concrete shall be as per relevant requirements of IS: 458. Compressive strength tests shall be conducted on 15 cm cubes in accordance with the relevant requirements of IS: 456 and IS: 516.

Curing

Pipes manufactured in compliance with IS: 458 shall be either water cured or steam cured in accordance with the relevant requirements of IS: 458.

Dimensions

The internal diameter, wall thickness and length of barrel and collar of pipes, reinforcement (longitudinal and spiral), type of ends and minimum clear cover to reinforcement and strength test requirements shall be as per the relevant clauses / tables of IS:458 for different classes of pipes.

The tolerances regarding overall length, internal diameter of pipes or sockets and barrel wall thickness shall be as per relevant clause of IS: 458.

Workmanship and Finish

Pipes shall be straight and free from cracks. The ends of the pipes shall be square with their longitudinal axis so that when placed in a straight line in the trench no opening between ends in contact shall exceed 3 mm in pipes upto 600mm diameter (inclusive), and 6 mm in pipes larger than 600 mm diameter.

The outside and inside surfaces of the pipes shall be smooth, dense and hard, and shall not be coated with cement wash or other preparation unless otherwise agreed to between the Engineer and the manufacturer or supplier.

The pipes shall be free from defects resulting from imperfect grading of the aggregate, mixing or moulding.

The pipes shall be free from local dents or bulges greater than 3 mm in depth and extending over a length in any direction greater than twice the thickness of barrel.

The deviation from straight in any pipe throughout its effective length, tested by means of rigid straight edge parallel to the longitudinal axis of the pipe shall not exceed, for all diameters 3 mm for every meter run.

Testing

All pipes for testing purposes shall be selected at random from the stock of the manufacturer and shall be such as would not otherwise be rejected under the criteria of tolerances as mentioned in IS: 458.Engineer reserve the right to attend all testing.

During manufacture, tests on concrete shall be carried out as per IS: 456. The manufacturer shall supply, when required to do so by the Engineer the results of compressive tests of concrete cubes and split tensile tests of concrete cylinders made from the concrete used for the pipes. The manufacturer shall supply cylinders or cubes for test purposes required by the Engineer and such cylinders or cubes shall withstand the tests prescribed as per IS:458. Every pressure pipe shall be tested by the manufacturer for the hydrostatic test pressure. For non-pressure pipes, 2 percent of the pipes shall be tested for hydrostatic test pressure.

The specimen of pipes for the following tests shall be selected in accordance with relevant clause of IS: 458 and tests in accordance with the methods described in IS: 3597.

i) Hydrostatic test
ii) Three edge bearing test
iii) Absorption test
iv) Visual Examination

Sampling and Inspection

In any consignment, all the pipes of same class and size and manufactured under similar conditions of production shall be grouped together to constitute a lot. The conformity of a lot to the requirements of this Employer's Requirements shall be ascertained on the basis of tests on pipes selected from it.

The number of pipes to be selected from the lot for testing shall be in accordance with Table 15 of IS: 458.

Pipes shall be selected at random. In order to ensure randomness, all the pipes in the lot may be arranged in a serial order and starting from any pipe, every pipe be selected

till the requisite number is obtained, or being the integral part of N/n where N is the lot size and n is the sample size.

All pipes selected shall be inspected by Engineer for dimensional requirements, finish and deviation from straight. A pipe failing to satisfy one or more of these requirements shall be considered as defective.

The number of pipes to be tested shall be in accordance with column 4 of Table 15 of IS:458. These pipes shall be selected from pipes that have satisfied the requirements mentioned in the above clause.

A lot shall be considered as conforming to the requirements of IS:458 if the following conditions are satisfied.

The number of defective pipes shall not be more than the permissible number given in column 3 of Table 15 of IS: 458.

All the pipes tested for various tests shall satisfy corresponding requirements of the tests.

In case the number of pipes not satisfying requirements of any one or more tests, one or two further samples of same size shall be selected and tested for the test or tests in which the failure has occurred. All these pipes shall satisfy the corresponding requirements of the test.

All result of tested data must be prepared by contractor at site so that the Engineer shall make decision of "fail or pass" at once. All cost for the test shall be borne by the Contractor.

Marking

The following information shall be clearly marked on each pipe:

a) Internal and External diameter and length of pipe
b) Class of pipe
c) Date of manufacture and
d) Name of manufacturer or his registered trade mark or both.

Jointing

General

Jointing of RCC pipes shall be done as per the requirements of following Employer's Requirements and as per the relevant IS standard. After jointing, extraneous material, if any, shall be removed from the inside of the pipe and the

newly made joints shall be thoroughly cured. In case, rubber sealing rings are used for jointing, these shall conform to IS: 5382. The pipe joint work must be done neatly and keep even slope and level for pipe laying works.

Spigot and Socket joint (Rigid)

The spigot of each pipe shall be slipped home well into the socket of the pipe previously laid and adjusted in the correct position. The opening of the joint shall be filled with stiff mixture of cement mortar which shall be rammed with caulking tool. This joint is used for low pressure pipe line.

Collar Joint (Rigid)

After laying the RCC pipes at proper alignment and gradient their abutting faces shall be coated with hot bitumen in liquid condition by means of a brush. The wedge-shaped groove in the end of the pipe shall then be filled with a tarred gasket in one length for each joint. The collar shall then be slipped over the end of the pipe and the next pipe butted well against the tarred gasket by suitable appliances approved by the Engineer so as to thoroughly compress the tarred gasket into the grooves, care being taken that the concentricity of the pipes and levels are not disturbed during this operation.

The collar shall then be place symmetrically over the end of the two pipes and the space between the inside of the collar and the outside of the pipe filled with a mixture of cement and sand to withstand any stress and prevent any water leakage, tempered with just sufficient water to have a consistency of the semi-dry conditions, well packed and thoroughly rammed with caulking tools. The joints shall be finished off with a fillet sloping at 45^{0} to the side of the pipe. The finished joints shall be protected and cured thoroughly as directed by the Engineer. Any plastic solution or cement mortar that may have been squeezed into the inside of the pipe shall be removed so as to leave the inside of the pipe perfectly clean.

Flush Joint (Internal)

This joint shall be generally used for culvert pipes of 900 mm diameter and over. The ends of the pipes are specially shaped to form a self centering joint with an internal jointing space 13 mm wide. The finished joint is flush with both inside and outside with the pipe wall. The jointing space is filled with cement mortar mixed sufficiently dry to remain in position when forced with a trowel or rammer.

Flush Joint (External)

This joint is suitable for pipes which are too small for jointing from inside. This joint is composed of specially shaped pipe ends. Each end shall be butted against each other and adjusted in correct position. The jointing space shall then be filled with cement

mortar sufficiently dry and finished off flush. Great care shall be taken to ensure that the projecting ends are not damaged as no repairs can be readily affected from inside the pipe.

Spigot and Socket (Semi-flexible)

This joint is composed of specially shaped spigot and socket ends on the RCC pipes. A rubber ring shall be lubricated and then placed on the spigot which is forced into the socket of the pipe previously laid. This compresses the rubber ring as it rolls into the annular space formed between the two surfaces of the spigot and socket, stiff mixture of cement and mortar shall then be filled into the remaining annular space with a caulking tool.

Collar Joint (Semi-Flexible)

This joint is made up of a loose collar which covers two specially shaped pipe ends. Each end shall be fitted with a rubber ring which when compressed between the spigot and collar, seals the joint. Stiff mixture of cement mortar shall then be filled to withstand stress and prevent any water leakage, into the remaining annular space and rammed with a caulking tool.

Spigot and Socket Joint (Flexible)

The RCC pipe with the rubber ring accurately positioned on the spigot shall be pushed well home into the socket of the previously laid pipe by means of uniformly applied pressure with the aid of a jack or similar appliance. The RCC pipes shall be of spigot and socket type and rubber rings shall be used, and the manufacturer's instructions shall be deemed to form a part of these Employer's Requirements. The rubber rings shall be lubricated before making the joint and the lubricant shall be soft soap water or an approved lubricant supplied by the manufacturer.

Cleaning of Pipes

As soon as a stretch of RCC pipes has been laid complete from manhole to manhole or for a stretch as directed by the Engineer, Contractor shall run through the pipes both backwards and forwards a double disc or solid or closed cylinder 75 mm less in diameter than the internal diameter of pipes. The open end of an incomplete stretch of pipe line shall be securely closed as may be directed by the Engineer to prevent entry of mud or silt etc.

If as a result of the removal of any obstructions the Engineer considers that damages may have been caused to the pipe lines, he shall be entitled to order the stretch to be tested immediately. Should such test prove unsatisfactory, contractor shall amend the work and carry out such further tests as are required by the Engineer.

It shall also be ascertained by contractor that each stretch from manhole to manhole or the stretch as directed by Engineer is absolutely clear and without any obstruction by means of visual examination of the interior of the pipe line suitably enlightened by projected sunlight or otherwise.

Testing at work site

After laying and jointing of RCC pipes is completed the pipe line shall be tested at work site as per the following Employer's Requirements and as directed by the Engineer. All equipment for testing at work site shall be supplied and erected by contractor. Water for testing of pipes shall be arranged by him. Damage during testing shall be contractor's responsibility and shall be rectified by him to full satisfaction of the Engineer. Water used for the test shall be removed from pipes and not released to the excavated trenches.

After the joints have thoroughly set and have been checked by the Engineer and before back filling the trenches, the entire section of the sewer or storm water drain shall be proved by the contractor to be water tight by filling in pipes with water to the level of 1.50m above the top of the highest pipe in the stretch and heading the water up for a period of one hour. The apparatus used for the purpose of testing shall be approved by the Engineer. Contractor if required by the Engineer shall dewater the excavated pit and keep it dry during the period of testing. The loss of water over a period of 30 minutes should be measured by adding water from a measuring vessel at regular 10 minutes intervals and noting the quantity required to maintain the original water level. For the approval of this test the average quantity added should not exceed 1 liter/ hour/100 linear metres / 10mm of nominal internal diameter. Any leakage including excessive sweating which causes a drop in the test water level will be visible and the defective part of the work should be removed and made good.

In case of pressure pipeline, the completed stretch of pipeline shall be tested for site test pressure. The site test pressure should not be less than the maximum operating pressure plus the calculated surge pressure, but in no case should it exceed the hydrostatic test pressure as specified in IS: 458.

All of results of test and inspection data must be prepared by contractor at site so that the Engineer shall make decision of "fail or pass" at once. All cost for the inspection shall be borne by the Contractor.

3.22. Steel Cylinder Pipes and Specials

3.22.1 Design

In general the design of steel cylinder pipes with concrete lining and coating shall conform to clause 8 of IS 1916. In addition to above, in case of buried pipe line, the pipe shall also be designed for the Earth load, and traffic load.

3.22.2 Manufacturing

General

Steel cylinder pipes and specials with concrete lining and coating shall be systematically checked for any manufacturing defects by experienced supervisors and a very high standard of quality shall be maintained. The pipes and specials shall be inspected by Engineer at site and factory, and defects noticed, if any, such as protrusions, grooves, dents, notches, etc. shall be rectified, if agreed to by the Engineer. Care shall be taken that the resulting wall thickness does not become less than the minimum specified. If the wall thickness becomes less than the minimum specified, as per Table 1 of IS: 1916, the damaged portion should be cut out as cylinder and replaced by an undamaged piece of pipe at no extra cost to the Engineer.

The Engineer shall at all reasonable times have free access to the place where the pipes and specials are manufactured for the purpose of examining, inspection and testing the pipes and specials and for witnessing the test and manufacturing.

All tests specified either in this Employer's Requirement or in the relevant Indian Standards shall be performed by Supplier/Contractor at his own cost and in presence of the Engineer, if desired. For this sufficient notice before testing of the pipes and specials shall be given to the Engineer.

If the test is found unsatisfactory, the Engineer may reject any or all pipes and specials of that lot. The decision of the Engineer in this matter shall be final and binding on the Contractor.

-Materials

All material shall conform to Clause 7 of IS 1916.

-Manufacturing Process

Steel cylinder pipes with concrete lining and coating shall be manufactured as per Clause No.9 of IS: 1916 and specials shall be manufactured as per Clause 7 of IS:7322. In case of spiral welded pipes, they shall be manufactured as per Clause 3 of IS: 5504. Internal lining shall be upto the full length of the pipes and specials. However, external coating shall be done leaving about 100 mm length of the pipes and specials from their ends. The internal lining and external

coating to pipes and specials shall be done at factory. Before lining/coating by concrete/mortar the surface of pipes and specials shall be thoroughly cleaned. In the event that loose mill scale, tuberculation, or an accumulation of dirt, debris, oil or grease is present, it shall be removed from the surface by hand, by machine or both and given a coating of neat cement slurry.

Dimensions

The clear cover to the reinforcement whether steel cylinder or cage shall be not less than 9 mm for lining of pipe/special and 12 mm for coating of the pipe/special.

The permissible tolerance for diameter and length of pipe shall be as per Clause 4 of IS: 1916, whereas for diameter, arm length and angular deviation of specials the tolerance limit shall be as per Clause 6 of IS: 7322.

Workmanship and Finish

Workmanship and finish of pipe shall conform to Clause 4 of IS: 1916.

Testing

Each steel cylinder shall be subjected before lining/coating to a hydrostatic test under a water pressure equivalent to the test pressure in accordance with Clause 10 of IS:1916 and relevant provisions of IS:3597, provided that the whole of the area of the calculated reinforcement is used in the steel cylinder. In the case of pipes where a part of the principal reinforcement is provided in the cage, the steel cylinder shall be subjected to proportionately less hydrostatic test pressure.

Manufacturer's standard specials shall be hydrostatically tested before lining/coating. Where feasible, other specials shall be hydrostatically tested (before lining/coating) at factory. However, when this is not practicable, at the discretion of the Engineer, the unlined specials shall be tested by penetration test as per IS: 3658 or other approved means.

All of results of test and inspection data must be prepared by contractor at site so that the Engineer shall make decision of "fail or pass" at once. All cost for the inspection shall be borne by the Contractor

–Penetration Test

A suitable liquid penetrant (kerosene oil/Dye) is applied to the surface of the portion under examination and is permitted to remain there for sufficient time to allow the liquid to penetrate into any defects open at the surface. After the penetrate time, the excess penetrant which remains on the surface, is removed. Then a light colored powder absorbent called a developer is applied to the surface. This developer acts as a blotter and draws out a portion of the penetrant which had previously seeped into the surface openings. As the penetrant is drawn out it diffuses into the coating of the developer, forming indication of the surface discontinuities or flaws.

Marking

The following information shall be clearly marked on each pipe and special:

i) Internal diameter, external diameter and thickness
ii) Class of pipe and special with its serial number
iii) Date of manufacture and
iv) Name of manufacturer or his registered trade mark or both

Jointing

General

Jointing of steel cylinder pipes and specials with concrete lining and coating be done as per the relevant IS. After jointing, extraneous material if any, shall be removed from the inside of the pipe and special. The welding of joints for pipes and specials at work sites shall comply with 816. Electrodes used for welding shall comply with IS: 814.

Butt Welded Joint

After pipes and specials are laid in the trench, the faces of pipes/specials shall first be tack-welded alternately at one or more diametrically opposite pairs of points. After completing tack welding, full welding shall be carried out in suitable runs following a sequence of welding portions of segments diametrically opposite. After jointing the exposed surface of the steel cylinder of pipes and specials shall be coated with M20 cement concrete of sufficient thickness so as to make it flush with the adjoining both inner and outer faces of pipes and specials. The gap in the internal lining at the joints shall be filled with cement mortar (1:2) for pipes and specials larger than 600 mm diameter. The lining/coating shall be done after the field test in the section has been successfully completed.

-Lap Welded Joint with Slip-in-ends

In the case of pipes with plain or slip-in-ends, swaged end of the steel cylinder may be formed by heating one of its ends and expanding it or rolling it out to the required shape. The minimum depth and maximum clearance between the swaged end and the plain end of pipes for field welding shall be provided as directed by the Engineer. Lap welding shall be done from the external face at the junction of pipe and socket. After jointing the exposed surface of the steel cylinder of pipes and specials shall be coated with M20 cement concrete of sufficient thickness so as to make it flush with the adjoining both inner and outer faces of pipes and specials. The gap in the internal lining at the joints shall be filled with cement mortar (1:2) for pipes and specials larger than 600 mm diameter. The lining/coating shall be done after the field test in the section has been successfully completed.

–Flanged Joints

The flanges for steel cylinder pipes and specials shall be as per BS EN 1092-1/BS4504. Flanges shall be provided at the end of pipes or specials where valves, blank flanges etc. have to be introduced or flanged joints for the pipes are specified. The flanges shall have necessary bolt holes drilled. It might be necessary for contractor to follow the instructions and specifications given by the valve manufacturer. All bolts, nuts and packing material required for flanged joints shall be provided by the Contractor. Bolts and nuts shall conform to IS: 1367 whereas rubber gasket of required thickness shall conform to IS: 638.

The bolts shall be evenly tightened in comply with relevant BS standard. Random inspection shall be carried out by jointly the Engineer and the contractor.

Cleaning of pipes and specials

Contractor shall ascertain that each stretch of pipeline is absolutely clear and without any obstruction by means of visual examination of the interior of pipeline suitably lighted by projected sunlight or otherwise. The open end of an incomplete stretch of pipeline shall be securely closed as may be directed by the Engineer to prevent entry of mud or silt etc.

If as a result of the removal of any obstructions the Engineer considers that damages may have been caused to the pipeline, he shall be entitled to order the

stretch to be tested immediately. Should such test prove unsatisfactory, contractor shall amend the work and carry out such further tests as are required by the Engineer.

Testing at work site

After laying and jointing of steel cylinder pipes and specials with concrete lining and coating is completed the pipeline shall be tested at work site as per the following Employer's Requirements and as directed by the Engineer. All equipment for testing at work site shall be supplied and erected by Contractor. Water for testing of pipes shall be arranged by him. Damage during testing shall be Contractor's responsibility and shall be rectified by him to the full satisfaction of the Engineer. Water used for test shall be removed from pipes and not released to the excavated trenches.

Each section of the pipe line shall be slowly filled with clean water and all air shall be expelled from the pipeline. The pressure in the pipeline should then be raised and maintained by means of pump to the test pressure. The test pressure should not be less than 1 1/2 times the working pressure at the lowest point or the static head pressure, whichever is higher. Under the test pressure no leak or sweating shall be visible at the welded joints. The duration of test shall be not less than 24 hours. The exposed joints shall be carefully examined and all such joints showing visible leaks shall be rewelded. Any cracked or defective pipes and specials in consequences of this pressure test shall be removed and replaced by sound material by Contractor and the test shall be repeated to the satisfaction of the Engineer.

Proper arrangement of thrust blocks shall be provided during pressure testing or pipe laying works.

3.23 Steel Pipe work

Pipe/fitting material and dimensional standard shall conform to following :

Size mm (NB)	Material Specification (Steel)	Dimensional Standard
Pipes upto 150 mm	1239 PT, ERW, Black PT-1 HVY	1239 ERW
200 to 2400	2062	3589 – ERW 3589 for dimensions and minimum thickness. Pipe thickness shall be as per 2825

Size mm (NB)	Material Specification (Steel)	Dimensional Standard
Elbows upto 25	ASTM–A 105	ANSI B 16.11 3000 # S.W.
40 to 150	ASTM-A 234 GR WPB	ANSI B 16.9
200 & above (meters)	2062	LR. BE. Sch 40 ANSI B 31.1
Coupling upto 25	ASTM-A 105	ANSI B 16.11 3000 # S.W.
Tees 40 to 200	ASTM – A 234 GR WPB	ANSI B 16.9 BE, Sch 40
Above 200	IS 2062	IS 2825 (min. Pipe thickness)
Reducers upto 25	ASTM-A 105	ANSI B 16.11 3000 S.W.
40 to 200	ASTM-A 234 GR WPB	ANSI B 16.9 BE, Sch 40
Above 200	2062	IS 2825 (min. Thickness for larger pipes)
Flanges	2062	BS EN 1092-1
Bolts and all nuts	1367 C1 4.6/4.0 (except under-water service which shall be in SS304)	1364
Gaskets All	638 (rubber) reinforced	3 mm thickness

Facilities shall be provided for draining the pipe system and releasing air.

The pipework layout within pump stations shall have the approval of the pump manufacturer. Fluid velocities in suction pipework leading to pumps shall not exceed 1.6 m/s. Fluid velocities in delivery pipework leading from pumps shall not exceed 2.4 m/s.

The whole of the jointing work and materials necessary to fix and connect the pipes, including adequate and efficient pipe support shall be included in the Contract. The Contractor shall be responsible for ensuring that the internal surface of all pipework is thoroughly cleaned before and during erection and before commissioning.

Cleaning shall include removal of all dirt, rust, scale and welding slag due to Site welding. Before dispatch from the manufacturer's works, the ends of the pipes, branch pipes, etc., shall be suitably capped and covered to prevent any accumulation of dirt or damage. This protection shall not be removed until

immediately prior to connecting adjacent pipes, valves or pumps. All small bore pipes shall be blown through with compressed air before connection is made to instruments and other equipment. No point of passage of pipes through floors or walls shall be used as a point of support, except with the approval of the Employer.

Hydrostatic shop test for pipes and fittings shall be as per code/standard requirement. After erection at site, complete pipes and fittings shall be hydrostatically tested for a pressure of 1.5 times operating pressure.

Flanges, if fabricated in segments shall be fully radiographed and stress relieved. If fabricated out of billets/bars by cold rolling, welded flanges shall be radiographed and normalized.

Protection for pipes laid underground shall be by coating and wrapping system giving a final coat thickness of 4.5 mm may be employed. Such protection shall comprise 1.5 mm of coal tar primer application on a thoroughly cleaned surface, to be followed with fiber glass wraps set in coal tar enamel coats conforming to American Water Works Association specification C/203/57 for a total thickness of 3 mm. Such lining shall meet a spark test to be approved with a holiday detector of 10000 Volts.

The Contractor shall indicate on his detailed drawings what thrust blocks are required to anchor pipe work supplied by him. Particular care shall be taken to ensure that pipe work thrusts are, as far as possible, not transmitted to machinery or other associated apparatus.

Puddle flanges shall be fitted to pipes where the structure through which they pass is required to take thrust resulting from the pipe. Puddle flanges shall also be fitted where a water barrier is required. All puddle flanges shall be clearly shown on the drawings and the resultant thrust clearly indicated. Puddle flanges shall only be fitted with the prior approval of the Employer.

Buried pipes shall in addition be designed to withstand external loading exerted by soil, water, and live loads as relevant. The external ground water shall be taken at ground level for design purposes. Saddle type/bracket type support wherever required shall be designed and supplied for the above ground pipe lines.

All pipe joints shall be of the butt welded type. End preparations and fabrication requirements shall generally conform to I.S. 2825. Flanges, if fabricated in segments, shall be fully radiographed and stress relieved.

Laying of welded steel pipes shall meet the requirements of I.S. 5822.

Welded Joints for Steel Pipes

Welding of joints in steel pipes shall be carried out manually by the metal arc welding process complying with AWWA Standard C206.

Before starting the welding of pipe joints in the Works the Contractor shall submit for the Engineer's approval details of the plant, methods and materials he proposes to use, including make and size of electrodes, number of runs, current strength and arrangements for air testing of individual joints.

Welding shall only be carried out by welders approved by the Engineer and each welder shall identify his work by means of a stenciled mark.

Welded joints other than for closing lengths shall be of the spherical spigot and socket type. For pipes of 675 mm diameter and smaller the pipe joint shall be welded externally. For pipes larger than 675 mm the pipe shall be welded internally and a sealing weld made externally.

All parts to be welded shall have loose scale, slag, rust, paint and other foreign matter removed by means of a wire brush and shall be left clean and dry. All scale and slag shall be removed from each weld run when it is completed. Pipes manufactured with longitudinal or spiral welds shall be lined up before jointing so that these welds are at least 15° apart around the joint circumference.

For pipes larger than 900 mm diameter a triple run convex fillet weld shall be used. For pipes of 900 mm diameter or less a double run convex fillet weld shall be used. The minimum leg length of the fillet as deposited is to be equal to the full thickness of the pipe wall. The actual throat depth shall not be greater than 9/10th and not less than 7/10th of the minimum leg lengths as deposited. The depositing of the weld metal shall be carried out in such a manner as to ensure that all the welds have adequate root fusion and are of good clean metal free from cracks, gas holes, slag inclusions and all other impurities. The surface of the weld shall have an even contour with regular finish and shall indicate proper fusion with the parent metal. All slag shall be thoroughly removed after depositing each run of welding by light hammering with a chipping hammer followed by wire brushing. Any welds showing cracks or other cavities or in which the weld metal tends to overlap on to the parent metal without proper

fusion or containing any other defects whatsoever shall be cut out and rewelded to the satisfaction of the Engineer at the Contractor's expense.

At closing lengths where two plain ended pipes are to be joined by a welded joint the gap between the two ends shall not exceed 75 mm. An external steel sleeve collar, of a thickness not less than that of the pipe itself and approximately 300 mm in length shall be placed centrally over the two ends to be jointed and the end of each pipe shall then be fillet welded to the sleeve collar in accordance with the above procedure.

No weld or adjacent parts of the pipe shall be painted prior to inspection by the Engineer.

Welder Performance Test

The Contractor shall submit for the Engineer's approval the names of persons whom he proposes to employ as welders with evidence that, as a minimum preliminary qualification, they have passed the qualifying tests prescribed in Clause 11 of BS 2633 and possessed certificates from an independent testing authority. The Engineer may further require any such person to perform satisfactory test welds under Site conditions and on pipes similar to those for use in the Works, before approving his employment as a welder. The Contractor shall maintain an up-to-date list of welders approved by the Engineer and if ordered by the Engineer he shall remove from the approved list any welder whose workmanship, as demonstrated by the results of air pressure tests on individual welded joints, is below a reasonable standard of quality of consistency in the Engineer's opinion.

Testing of Welded Joints

Where directed by the Engineer welded joints on pipes larger than 675 mm diameter shall be subject to a nitrogen gas test after welding.

A tapped hole (approximately 6 mm diameter) shall be made in the socket end of each pipe by the Contractor and shall be fitted with a suitable non-return valve. Nitrogen, at 400 kPa pressure, shall then be pumped into the annular space between the spigot and socket and the pump disconnected.

If no drop in pressure occurs over the ensuing period of 30 minutes the test shall be deemed to be successful. If the test pressure cannot be maintained for 30 minutes all defects in the weld shall be cut back and rewelded and the test

reapplied until successful. The cost of initial and subsequent testing of defective welds shall be at the Contractor's own expense.

The Contractor shall provide all items necessary for the nitrogen tests including compressor, valves, gauges and tubing.

6.74.2 Hydraulic Losses

The frictional losses due to water flow in pipe work shall be computed, based on the following:

a) Straight Pipes: William-Hazen formula using C = 110

Head loss in mwc/m run of pipe =

$$6.815 \times \frac{(V)^{1.852} \times (1)}{(c)^{1.852} \times (D)^{1.167}}$$

Where V = flow velocity in m/s

D = pipe internal diameter in m

b) Valves

The losses in mwc shall be calculated as

$$k \times \frac{v^2}{2g},$$

Where v = flow velocity through the nominal diameter in m/s

$g = 9.81\ m/sec^2$

k = Coefficient as noted below;

k - for sluice valves = 0.2

for butterfly valves = 0.3

for non-return valves = 1.5

for penstocks = as furnished by the manufacturer with documentary evidence.

c) Fittings, specials

For specials like reducers, bell mouths, tees, elbows, etc, the `k' values shall be as recommended by the British Hydromechanics Research Association (BHRA), Volume 5, in the BHRA fluid Engineering Series.

Pipe work Protection

All underground steel piping shall have their external surfaces protected by application of one coal tar enamel coat, wrapping of fiberglass, one more coat of enamel and a final wrap of enamel impregnated fiberglass. Pipe surface shall be thoroughly cleaned by shot or sand blasting. Primer paint recommended by the enamel manufacturer for the grade of enamel used shall be applied over this cleaned surface within four hours of cleaning. The primer paint shall be thoroughly mixed and applied as recommended by the manufacturer and the coating shall be free of bubbles, globules, drips and runs. The primer shall be thoroughly dry before enamel is applied and the latter shall not be applied later than 3 days after application of primer. First flood coat of enamel shall be overlaid by a single spiral wrap of fiberglass overlapping at least 20 mm on pipe up to 250 mm diameter and 25 mm on larger diameter pipes. Enamel shall be heated slowly in clean kettles, equipped with indicating or recording thermometers (100°C to 350°C range), to the recommended temperature. The enamel shall be stirred continuously. It shall be seen that fiberglass impregnates in the flood coat. Second coat of enamel and second wrap of bitumen impregnated fiberglass shall be applied in the same way. The total thickness of the coating shall not be less than 2.5 mm. Each end of the pipe left bare for a distance of 150 mm for welding shall be hand coated and wrapped after field welding is completed and hydro tested. Testing of pipe protection shall be done as directed by the Engineer using elcometers, coating thickness guages, and bond test and holiday detectors.

External protection

All underground pipework having a cover less than 1.5 m and more than 4.5 m shall be encased with M 15 concrete of minimum 200 mm thick all around.

All underground pipelines having a cover more than 1.5 m shall be externally protected by guiniting of minimum 40 mm thick as per specification.

All above ground and pipes in galleries shall be externally painted with two coats of epoxy with minimum thickness of 180 microns.

Flexibility in Pipe work

The Contractor shall provide flexibility in the pipe work at joints in the main structures and shall submit proposals for the approval of the Engineer. Flexible joints or collars and cut pipes shall be allowed on all pipe work where necessary to allow for some margin of error in the building work.

Wherever possible flexible joints shall be provided with tie bolts or other means to transfer longitudinal thrusts as a whole so that external anchorages may be kept to a minimum. Flexible joints shall also be provided for case of erection and future dismantling. Particular care shall be taken to ensure that pipe work thrusts are not transmitted to machinery or associated apparatus.

The Contractor shall indicate on his detailed drawings what thrust blocks are required.

Puddle Flanges

Puddle flanges shall be fitted to pipes where the structure through which they pass is required to take thrust resulting form the pipe. Puddle flanges shall also be fitted where a water barrier is required. All puddle flanges shall be clearly shown on the drawing and the resultant thrust clearly indicated. Puddle flanges shall only be fitted with the Engineer prior approval.

Small Bore Pipes and Hoses

Small bore pipes and hoses shall be of non-flame propagating materials. They shall be arranged for easy dismantling for cleaning where appropriate, and if screwed joint or joints formed by solvent welding are proposed for any chemical line, a sufficient number of flanged or flexible joints shall be provided to enable the pipe work to be removed in sections without working from one end to the other of a particular run. Tees and cocks shall also be provided at convenient points for the connection of a pressure water supply to flush pipe work through as required.

All pipes and hoses shall be labelled to enable individual lines to be identified throughout their run. Racks or trays shall be fixed to the duct walls or walls of tanks and buildings and the chemical pipes shall be fixed to these racks or trays with clips which can easily be removed without dismantling adjacent pipes. The Contract includes for the supply and fixing of all such racks or trays. Full details of the type of hoses, pipes and racks of trays proposed, shall be submitted at the time of tendering.

Support of Pipe work and Accessories

All necessary supports, saddles, slings, fixing bolts and foundation bolts shall be supplied to support the pipe work and its associated equipment in an approved manner. Valve, meters, strainers, and other devices mounted in the pipe work shall be supported independently of the pipes to which they connect.

All brackets or other forms of supports, which can conveniently be so designed, shall be rigidly built up of steel by riveting or welding in preference to the use of castings.

No point of passage of pipes through floors or walls shall be used as a point of support, except with the approval of the Engineer.

After the collars and boxes or other fitting have been fixed in position, the floors, walls and roof structure will be made good by the Contractor.

6.75 Cast Iron Pipes

6.76

6.77 Manufacturing

6.78 General

6.79

6.80 C.I. pipes and fittings shall be systematically checked for any manufacturing defects by experienced supervisors and a very high standard of quality shall be maintained.

6.81

6.82 Engineer shall at all reasonable times have free access to the place where the pipes and fittings are manufactured for the purpose of examining and testing the pipes and fittings and for witnessing the test and manufacturing.

6.83

6.84 All tests specified either in this Employer's Requirements or in the relevant Indian Standards shall be performed by the supplier/contractor at his own cost and in presence of the Engineer if desired. For this, sufficient notice before testing of the pipes and fittings shall be given to the Engineer.

6.85

6.86 If the test is found unsatisfactory, the Engineer may reject any or all pipes and fittings of that lot. The decision of the Engineer in this matter shall be final and binding of the Contractor and not subject to any arbitration or appeal.

6.87

6.87.1.1 Materials

6.87.1.2

6.87.1.3 The general requirements relating to the supply of material shall be as per IS: 1387.

6.87.1.4

6.87.1.5 The material for pipes and fittings shall be of good quality cast iron conforming to IS: 210 (Grade -FG 150).

6.87.1.6

6.87.1.7 Dimensions

6.87.1.8

6.87.1.9 The internal diameter, thickness and length of barrel, dimensions of pipes and fittings shall be as per the relevant tables of IS: 1536/1537/1538 for different class of pipes and fittings.

6.87.1.10

6.87.1.11 The tolerances for pipes and fittings regarding dimensions and deviations from straight line in case of pipes shall be as per relevant IS codes.

6.87.1.12

6.87.1.13 The standard weight of uncoated pipes and fittings and the permissible tolerance shall be as per relevant IS codes.

6.87.1.14

6.87.1.15 Workmanship and Finish

6.87.1.16

6.87.1.17 The pipes and fittings shall be stripped, with all precautions necessary to avoid warping or shrinking defects. The pipes and fittings shall be free from defects, other than any unavoidable surface imperfections which result from the method of manufacture and which do not affect the use of the pipes in the opinion of Engineer.

6.87.1.18

6.87.1.19 The pipes and fittings shall be such that they could be cut, drilled or machined and may be accepted provided the hardness of the external unmachined surface does not exceed 230 HBS. In the case of spigot and socket pipes and fittings for lead joints, the socket shall be without the centering ring.

6.87.1.20

6.87.1.21 In the case of flanged pipes the flanges shall be at the right angles to the axis of the pipe and machined on face. The bolt holes shall be drilled and located symmetrically off the centre line. The bolt hole circle shall be concentric with the bore and bolt holes equally spaced. The flanges shall be integrally cast with the pipes and fittings and the two flanges of the pipe shall be correctly aligned.

6.87.1.22

6.87.1.23 Testing

6.87.1.24

6.87.1.25 Mechanical Tests

6.87.1.26

6.87.1.27 Mechanical tests shall be carried out during manufacture of pipes and fittings as specified in relevant IS codes. The results so obtained shall be considered to represent all the pipes and fittings of different sizes manufactured during that period and the same shall be submitted to the Engineer. The method for tensile tests and the minimum tensile strength requirement for pipes and fittings shall be as per relevant IS codes.

6.87.1.28

6.87.1.29 Brinell Hardness Test

6.87.1.30 —

6.87.1.31 For checking the Brinell hardness, the test shall be carried out on the test ring or bars cut from the pipes used for the ring test and tensile test in accordance with IS 1500.

6.87.1.32 —

6.87.1.33 Retests

6.87.1.34 —

6.87.1.35 If any test piece representing a lot fails in the first instance, two additional tests shall be made on test pieces selected from two other pipes from the same lot. If both the test results satisfy the specified requirements, the lot shall be accepted. Should either of these additional test pieces fail to pass the test, the lot shall be liable for rejection.

6.87.1.36 —

6.87.1.37 Hydrostatic test

6.87.1.38 —

6.87.1.39 For hydrostatic test at works, the pipes and fittings shall be kept under test pressure as specified in relevant IS codes for 15 seconds, they may be struck moderately with a 700 g hammer. They shall withstand the pressure test without showing any leakage, sweating or other defect of any kind. The hydrostatic test shall be conducted before coating the pipes and fittings.

6.87.1.40 —

6.87.1.41 Coating

6.87.1.42 —

6.87.1.43 Coating shall not be applied to any pipe and fitting unless its surface is clean, dry and free from rust. All pipes and fittings shall be coated externally and internally with the same material, by dipping in a tar or suitable base bath. The pipe and fitting may be either preheated before dipping or the bath may be uniformly heated. The coating material shall set rapidly with good adherence and shall not scale off. In all instances where the coating material has a tar or similar base, it shall be smooth and tenacious and hard enough not to flow when exposed to a temperature of 65° C, but not so brittle at a temperature of 0^0C as to chip off when scribed lightly with a penknife. In case of pipes and fittings which are imperfectly coated or where the coating does not set or conform to the required quality, the coating shall be removed and the pipes and fittings recoated.

6.87.1.44 —

6.87.1.45 In case the pipes are to be used for conveying potable water, the inside coating shall not contain any constituent soluble in such water or any ingredient which could impart any taste or odour whatsoever to the potable water after disinfection and suitable washing of the mains.

6.87.1.46

6.87.1.47 Marking

6.87.1.48

6.87.1.49 Each pipe and fitting shall have cast, stamped or indelibly painted on it the following appropriate marks:

6.87.1.50 The nominal diameter.

6.87.1.51 Flow direction and line marks for installation

6.87.1.52 Class reference

6.87.1.53 Mass of pipe

6.87.1.54 Date of manufacture and

6.87.1.55 Manufacturer's name, initials or identification mark.

6.87.1.56

6.87.1.57 Marking shall be done as per relevant IS code.

6.87.1.58

6.87.1.59 Jointing

6.87.1.60

6.87.1.61 General

6.87.1.62

6.87.1.63 Jointing of CI pipes and fittings shall be done as per the requirements of following Employer's Requirements and as per the relevant IS. After jointing, extraneous material, if any, shall be removed from the inside of the pipe. In case, rubber sealing rings are used for jointing, these shall conform to IS: 5382.

6.87.1.64

6.87.1.65

6.87.1.66

6.87.1.67 Tyton joints

6.87.1.68

6.87.1.69 In jointing cast iron spigot and socket pipes and fittings with tyton flexible joints the contractor shall take into account the manufacture's recommendations as to the methods and equipment to be used in assembling the joints. In particular the contractor shall ensure that the spigot end of the pipe to be jointed is smooth and has been properly chamfered, that the rubber ring as per IS: 5382, is correctly positioned in line, before the joint is made. The rubber rings and any recommended

lubricant shall be obtained only through the pipe supplier or as otherwise directed by Engineer.

6.87.1.70

6.87.1.71 Flanged Pipes

6.87.1.72

6.87.1.73 The gaskets used between flanges of pipes shall be compressed fibre board or natural/synthetic rubber conforming to IS: 638, of thickness between 1.5 to 3 mm. The fibre board shall be impregnated with chemically neutral mineral oil and shall have a smooth and hard surface. Its weight per square metre shall be not less than 112 g/mm thickness.

6.87.1.74

6.87.1.75 Each bolt should be tightened a little at a time taking care to tighten diametrically opposite bolts alternately. The practice of fully tightening the bolts one after another is highly undesirable. The bolts shall be of mild steel unless otherwise specified.

6.87.1.76

6.87.1.77 Cleaning of Pipes and Fittings

6.87.1.78

6.87.1.79 The Contractor shall ascertain that each stretch of pipeline is absolutely clear and without any obstruction by means of visual examination of the interior of pipeline suitably lighted by projected sunlight or otherwise. The open end of an incomplete stretch of pipeline shall be securely closed as may be directed by the Engineer to prevent entry of mud or silt etc.

6.87.1.80

6.87.1.81 If as a result of the removal of any obstructions the Engineer considers that damages may have been caused to the pipeline, he shall be entitled to order the stretch to be tested immediately. Should such test prove unsatisfactory, contractor shall amend the work and carry out such further tests as are required by the Engineer.

6.87.1.82

6.87.1.83 Testing at work site

6.87.1.84

6.87.1.85 After the pipes and fittings are laid, jointed and the trench partially backfilled except at the joints the stretch of pipe line as directed by Engineer shall be subjected to pressure test and leakage test. Where any section of the pipeline is provided with concrete thrust blocks or anchorages, the pressure test shall not be made until at least five days have elapsed after the concrete was cast. If rapid hardening cement has been used in these blocks or anchorages, the tests shall not be made until atleast two days have elapsed.

6.87.1.86

6.87.1.87 Each section of the pipe line shall be slowly filled with water and all air shall be expelled from the pipe by tapping at points of highest elevation before the test is made and plugs inserted after the tests have been completed. The specified test pressure based on the elevation of the lowest point of the line or section under test and corrected to the elevation of the test gauge, shall be applied by means of a pump connected to the pipe as directed by the Engineer.

6.87.1.88

6.87.1.89 The duration of test shall not be less than 5 minutes. The exposed joints shall be carefully examined and all such joints showing visible leaks shall be recaulked until water tight. Any cracked or defective pipes and fittings in consequence of this pressure test shall be removed and replaced by sound material by Contractor at no extra cost to the Engineer and the test shall be repeated to the satisfaction of the Engineer.

6.87.1.90

6.87.1.91 After the satisfactory completion of pressure test, the section of pipe line shall be subjected to leakage test. The duration of test shall be 2 hours. No pipe installation shall be accepted until the leakage is less than the number of cm^3/h as determined by the formula:

6.87.1.92

6.87.1.93 $$q_L = \frac{ND\sqrt{P}}{3.3}$$

6.87.1.94

6.87.1.95

6.87.1.96

6.87.1.97 Where,

6.87.1.98 q_L = The allowable leakage in cm^3/hr

6.87.1.99 N = Number of joints in the length of the pipeline

6.87.1.100 D = Diameter in mm, and

6.87.1.101 P = The average test pressure during the leakage test in Kg/cm^2

6.87.1.102

6.87.1.103 Should any test of pipe laid indicate leakage greater than that specified above, the defective joints shall be repaired by Contractor at no extra cost to the Engineer until the leakage is within the specified allowance.

6.87.1.104

6.87.1.105 Necessary equipment and water used for testing shall be arranged by Contractor at his own cost. Damage during testing shall be Contractor's responsibility and shall be rectified by him at no extra cost

to the Engineer. Water used for testing shall be removed from the pipe and not released in the excavated trenches.

6.87.1.106

6.87.1.107 After the tests mentioned above are completed to the satisfaction of the Engineer, the backfilling of trenches shall be done as per the Employer's Requirements specified elsewhere.

6.87.1.108

6.87.1.109 Un plasticised PVC Pipes and Fittings

6.87.1.110

6.87.1.111 Unplasticised polyvinyl chloride pipes, fittings and specials shall be to BS 3505 for potable water and BS 4346: Part 1 for fittings.

6.87.1.112

6.87.1.113 The pipes shall be of the spigot and socket type with approved gasket type flexible joint. The rubber gaskets shall be to BS 2494, Class C.

6.87.1.114

6.87.1.115 Where PVC pipes, fittings and specials are to be connected to cast iron, stainless steel or steel pipes, 'Viking Johnson' type flange adaptors or stepped couplings shall be used.

6.87.1.116

6.87.1.117 Polyethylene Pipes

6.87.1.118

6.87.1.119 Polyethylene pipes shall comply with BS 6437. The welding method shall be adapted to international standard and contractor shall obtain the approval of the Engineer before proceeding with such works.

6.87.1.120

6.87.1.121 Rubber Hosing

6.87.1.122

6.87.1.123 Rubber hosing shall conform to BS 5119, Type 2. It shall be capable of handling chlorine and sulphur dioxide solutions at a working pressure of 12 bar.

6.87.1.124

6.87.1.125 Copper Tubes and Fittings

6.87.1.126

6.87.1.127 Copper tubing and fittings for work above ground level shall comply with BS 2871 and BS 864: Part 2 respectively and be jointed with capillary joints. For underground location the copper pipe shall be to BS 2871: Part 1.

6.87.1.128

6.87.1.129 Flanged Joints

6.87.1.130

6.87.1.131 All flanges shall comply with BS EN 1092-1/BS 4504. The nominal pressure rating for particular flanges shall be at least equal to the highest pressure rating of the pipes or fittings to which they are attached, but with a minimum nominal pressure of PN 10. All flanges shall be provided with all necessary nuts, bolts, washers and gaskets. In general, valves shall have flanged body ends.

6.87.1.132

6.87.1.133 All flanged joints which are buried or in chambers shall be protected with Densomastic and Densotape wrapping, applied in accordance with the manufacturer's instructions.

6.87.1.134

6.87.1.135 Flanges shall be installed on the pipes in the factory and field welding of flanges shall only be allowed with the approval of the Engineer.

6.87.1.136

6.87.1.137 Where pipework outside pumping stations and surge vessel chambers is cathodically protected, an insulated flange shall be incorporated at the first flange inside the structure. These flanges shall be tested to ensure that electrical insulation is achieved.

6.87.1.138

6.87.1.139

6.87.1.140

6.87.1.141 Gaskets and Joint Rings

6.87.1.142

6.87.1.143 Joint rings shall be manufactured to conform with BS 2494 and shall be of chloroprene rubber or other approved synthetic material suitable for temperatures up to 80°C.

6.87.1.144

6.87.1.145 Gaskets may be inside the bolt circle type and shall comply with BS 4865: Part 1. Alternatively the gasket shall be to the full diameter of the flange, drilled to suit the appropriate bolt provisions.

6.87.1.146

6.87.1.147 Chloroprene rubber with a hardness of 71 to 80 IRHD shall be used.

6.87.1.148

6.87.1.149 Joints shall be made in accordance with manufacturer's instructions or as specified herein.

Until immediately required for incorporation in a joint, each rubber ring or gasket shall be stored in the dark, free from the deleterious effects of heat or cold, and kept flat so as to prevent any part of the rubber being in tension.

Only lubricants recommended by the manufacturer shall be used in connection with rubber rings and these lubricants shall not contain any soluble constituent, shall be suitable for the climatic conditions at the Site and shall contain an approved bactericide.

After cleaning the flanges the gaskets shall be fitted smoothly to the flange and the joint shall be made by tightening the nuts to finger pressure first. Thereafter the final tightening of the nuts shall be made by gradually and evenly tightening bolts in diametrically opposite positions using standard spanners.

Graphite grease shall be applied to the threads of bolts before joints are made.

Flexible Couplings and Flange Adaptors

Flexible couplings and flange adaptors shall be of the Viking Johnson or similar approved pattern and be assembled in accordance with the manufacturer's instructions and protected, if buried or in chambers with Densomastic and Densotape wrapping applied in accordance with the manufacturers' instructions. Flexible joints shall be harnessed or tied where necessary

Storage & Shipment

Protection of Pipes and Fittings for Shipment

Except where otherwise specified all items shall have received their complete protective coatings before dispatch from the manufacturer's works and shall be additionally protected by approved means for the period of transit, storage and erection, against corrosion and accidental damage.

For the protection of pipe linings and in particular for protecting cement mortar linings from drying out, protective metal or timber discs shall be fitted over the ends of pipes and fittings. Similar timber protective discs shall be attached to all flanges of pipes and fittings, by means of bolts specifically provided for the purpose and which shall be discarded when the item is incorporated in the Works. The sleeves and flanges of flexible joints shall be wired together in suitable bundles.

6.87.2 Storage of Pipeline Materials

Pipes and fittings shall be stored raised off the ground, and shall be carefully supported, cushioned and wedged. Pipes shall not rest directly on one another and shall not be stacked more than four pipes high or two pipes high in the case of pipes of 500 mm diameter or over. Special care shall be taken to ensure that

flexible pipes are cradled and supported in a manner that prevents any distortion of the pipes.

Couplings and joints (and all components thereof) and other similar items shall be stored in dry conditions, raised from the ground in sheds or covered areas.

Storage areas shall be carefully set out to facilitate unloading, and checking of materials with different consignments stacked or stored separately with identification marks clearly visible.

Where items to be stored have a limited shelf life or require special storage arrangements, the method of storage shall be to the approval of the Engineer and in accordance with the manufacturer's instructions.

All pipes and fittings supplied as spares shall have end covers which are proof against the entry of sand and vermin. Mortar lined pipes and fittings shall have end covers which form a complete seal, provision being made to accommodate the effects of temperature changes. Pipes and fittings supplied as spares shall have a temporary white external finish and shall be stored sheltered from the direct rays of the sun.

End covers and protection shall not be removed until incorporation of the pipes and fittings into the Works.

Transportation of Pipes and Fittings

Any vehicle on which pipes are transported shall have a body of such length that the pipes do not overhang. Large pipes shall be placed on cradles and the loads properly secured during transit. The pipes shall be handled in accordance with the manufacturer's recommendations.

Approved slings shall be used and all hooks and dogs and other metal devices shall be well padded. Hooks engaged on the inner wall surface at pipe ends shall not be used. Steadying ropes shall be employed. The positions of lifting slings shall ensure that stresses and tendency towards deformation in the pipes are kept at a minimum.

Pipe handling equipment shall be maintained in good repair and any equipment which in the opinion of the Engineer may cause damage to the pipes shall be discarded.

Under no circumstances shall pipes be dropped, be allowed to strike one other, be rolled freely or dragged along the ground.

Inspection of Pipes and Fittings

Before incorporating into the Works each pipe shall be brushed out and carefully examined for soundness. Damaged pipes which in the opinion of the Engineer cannot be satisfactorily repaired shall be rejected and removed from Site.

Damage to pipe coatings or linings shall be repaired to the satisfaction of the Engineer.

Built in Pipe work and other Plant

The pipes and other Plant in water retaining structures shall, wherever possible, be built in as the work on the structure proceeds. The Contractor shall ensure that delivery of the requisite pipe work and other Plant is in accordance with the requirements of the programme.

Where a pipe subject to thrust passes through a concrete structure or where an external seal is required, a puddle flange shall be used. The puddle flange dimensions shall be to BS EN 1092-1/BS 4504 but shall be undrilled. The exterior of the pipe shall be cement washed symmetrically about the puddle flange by the manufacturer for a length at least equivalent to the thickness of the wall through which it passes.

The Contractor shall be responsible through every stage of the Works for checking the correctness of the setting of built-in Plant and shall satisfy himself they are positioned in accordance with his approved drawings.

6.88 Pipe laying

6.88.1 Carting & Handling

Pipes and fittings /specials shall be transported from the factory to the work sites at places along the alignment of pipeline as directed by the Engineer. Contractor shall be responsible for the safety of pipes and fittings/specials in transit, loading/unloading. Every care shall be exercised in handling pipes and fittings/specials to avoid damage. While unloading, the pipes and fittings/specials shall not be thrown down from the truck on to hard surfaces. They should be unloaded on timber skids with steadying ropes or by any other approved means. Padding shall be provided between coated pipes, fittings/specials and timber skids to avoid damage to the coating. Suitable gaps between pipes should be left at intervals in order to permit access from one side to other. In case of spigot socket pipes, care should be taken regarding orientation of pipes while unloading. As far as possible pipes shall be unloaded on one side of the trench only. The pipes shall be checked for any visible damage (such as broken edges, cracking or spalling of pipe) while unloading and shall be sorted out for reclamation. Any pipe which shows sufficient damage

to preclude it from being used shall be discarded. Dragging of pipes and fittings/specials along concrete and similar pavement with hard surfaces shall be prohibited.

6.88.2 Storage

Each stack of pipes shall contain only pipes of same class and size, with consignment or batch number marked on it with particulars of suppliers wherever possible. Storage shall be done on firm level and clean ground and wedges shall be provided at the bottom layer to keep the stack stable. The stack shall be in pyramid shape or the pipes laid lengthwise and crosswise in alternate layers. The pyramid stack shall be made for smaller diameter pipes for conserving space in storing them. The height of the stock shall not exceed 1.5 m.

Fittings/Specials shall be stacked under cover and separated from pipes.

Rubber rings shall be stored in a clean, cool store away from windows, boiler, electrical equipment and petrol, oils or other chemicals. Particularly in the field where the rubber rings are being used it is desirable that they are not left out on the ground in the sun or overnight under heavy frost or snow conditions.

6.89 Laying

6.89.1 Excavation

Before excavating the trench the alignment of pipeline shall be approved by the Engineer. The excavation of trenches and pits for manholes/ chambers shall be carried out in accordance with the Employer's Requirements described elsewhere and shall be done such that it does not get far ahead of the laying operation as approved by the Engineer.

To protect persons from injury and to avoid damage to property, adequate barricades, construction signs, red lanterns and guards as required shall be placed and maintained during the progress of the construction work and until it is safe for the traffic to use the roadways. The relevant Indian Standards and the rules and regulations of local authorities in regards to safety provisions shall be observed.

Suitable fencing shall be provided along the sides of trenches and pits. The posts of fencing shall be of timber securely fixed in the ground not more than 3 m apart and they shall not be less than 75 mm in diameter or less than 1.2m

above surface of the ground. There shall be two rails, one near the top of the post and the other about 450mm above the ground and each shall be from 50mm to 70mm in diameter and sufficiently long to run from post to post to which they shall be bound with strong rope. The method of projecting rails beyond the post and tying them together where they meet will not be allowed on any account. All along the edges of the excavation trenches a bank of earth about 1.2 m high shall be formed where required by the Engineer for further protection.

The road metal and also the rubble packing shall first be stripped off for the whole width of the trench/pit and separately deposited in such place or places as may be determined by the Engineer.

During excavation, large stones and rubble shall be separated and removed from the excavated soil and stacked separately. The material from excavation shall be deposited on either side of the trench leaving adequate clear distance from the edges of the trench and pit, or as may be necessary to prevent the sides of the trench pit to slip or fall, or at such a distance and in such a manner as to avoid covering fire hydrants, sluice valves, manholes and covers etc. and so as to avoid abutting the wall or structure or causing inconvenience to the public and other service organizations or otherwise as the Engineer may direct.

Contractor shall take into account additional excavation if any as the Engineer may require in order locating the position of water pipes, drains, sewers etc. or any other works which may be met with, in or about the excavation of trenches/pits while quoting the rates for excavation of trenches /pits while quoting the rates of excavation. Such service lines if met with during excavation shall be properly maintained by Contractor, by means of shoring, strutting, planking over, padding or otherwise as the Engineer may direct, and shall be protected by the Contractor from damage during the progress of the work. All precautions shall be taken during excavation and laying operations to guard against possible damage to any existing structure /pipe line of water, gas, sewage etc.

Utmost care shall be taken to see that the width of the trench at the top of pipe is not more than the minimum requirement. In case additional width is required it shall be provided only in the top portion from the ground level upto 300 mm above the top of pipe. If any extra width is provided in the area below this portion, Contractor shall have to provide remedial measures in the form of lime concrete or rubble masonry otherwise at the discretion and to the satisfaction of the Engineer. If rock is met with, it shall be removed to 15 cm below the bottom

of pipes and fittings/specials and the space resulting shall be refilled with granular materials and properly consolidated. Bottom of trenches/pits shall be saturated with water well rammed wherever the Engineer may consider it necessary to do so.

Wherever a socket or collar of pipe or fitting/ special occurs, a grip is to be cut in the bottom of the trench or concrete bed to a depth of at least 75 mm below the bed of the pipe so that the pipe may have a fair bearing on its shaft and does not rest upon its socket. Such grip shall be of sufficient size in every respect to admit the hand all around the socket in order to make the joint and the grip shall be maintained clear until the joint has been approved by the Engineer.

When welding is to be carried out with the pipes and specials in the trench, additional excavation of not more than 60cm in depth and 90 cm in length shall be made at joints in order to facilitate welding.

The excess excavated material shall be carried away from site of works to a place up to a distance as directed by the Engineer. This shall be done immediately so as not to cause any inconvenience to the public or traffic. If the instructions from Engineer are not implemented within seven days from the date of instructions to cart the materials and to clear the site, the same shall be carried out by the Engineer and any claim or dispute shall not be entertained in this respect.

Dewatering

During the excavation, if subsoil water is met with Contractor shall provide necessary equipment and labourers for dewatering the trenches. The Contractor shall also make necessary arrangement for the disposal of drained water to nearby storm water drain or in a pit if allowed by the Engineer. In no case the water shall be allowed to spread over the adjoining area. Before discharging this water into public sewer/drain, the Contractor shall take necessary permission from the local authorities.

Special Foundation in Poor Soil

Where the bottom of the trench and sub grade is found to consist of material which is unstable to such a degree that in the opinion of the Engineer, it cannot be removed and replaced with an approved material thoroughly compacted in place to support the pipe properly, a suitable foundation for the pipes, consisting of piling, timbers or other materials, in accordance with relevant drawings to be prepared by the Contractor and as instructed by the Engineer shall be constructed.

Wooden Shoring

Contractor shall suitably design polling boards, waling and struts to meet different soil conditions that might be encountered in excavating trenches/pits. The horizontal and vertical spacing of struts shall be such that not only the sides of trenches shall be prevented from collapse but also easy lowering of pipe in trenches shall be ensured without creating undue obstructions for the excavation of the work. Any inconvenience and/or delay that might be caused in lowering pipes in trenches as a result of adopting improper spacing of struts by Contractor shall be his sole responsibility. No part of shoring shall at any time be removed by Contractor without obtaining permission from the Engineer. While taking out shoring planks the hollows of any form must simultaneously be filled in with soft earth well rammed with rammers and with water.

The Engineer may order portions of shoring to be left in the trenches /pits at such places, where it is found absolutely necessary to do so to avoid any damage which may be caused to buildings, cables, gas mains, water mains, sewers etc. in close proximity of the excavation, by pulling out the shoring from the excavations. The Contractor shall not claim, on any reason whatsoever, for the shoring which may have been left in by him at his own discretion.

6.89.2 Steel Plate Shoring

6.89.3

6.89.4 Where the subsoil conditions are expected to be of a soft and unstable character in trench/pit excavation, the normal method of timbering may prove insufficient to avoid subsidence of the adjoining road surfaces and other services. In such circumstances, the Contractor will be required to use steel trench sheeting or sheet piling adequately supported by timber struts, waling etc., as per the instructions, manner and method directed by the Engineer. Contractor shall supply pitch, drive and subsequently remove trench sheeting or piling in accordance with other items of the Employer's Requirements.

6.89.5

6.89.6 Boning Staves and Sight Rails

6.89.7

6.89.8 In laying the pipes and fittings/ specials the centre for each manhole / chamber or pipeline shall be marked by a peg. Contractor shall dig holes for and set up two posts (about 100 x 100 x 1800 mm) at each manhole/chamber or junction of pipelines at nearly equal distance from the peg and at sufficient distances there from to be well clear of all intended excavation, so arranged that a sight rail when fixed at a certain level against the post shall cross the centre line of the manhole/chamber or pipe lines. The sight rail shall not in any case be more than 30 m apart; intermediate rails shall be put up if directed by the Engineer.

6.89.9

6.89.10 Boning staves of 75 mm x 50 mm size shall be prepared by Contractor in various lengths, each length being of a certain whole number of meters and with a fixed tee head and fixed intermediate cross pieces, each about 300 mm long. The top-edge of the cross piece must be fixed below the top-edge of the tee-head at a distance equal to the outside diameter of the pipe or the thickness of the concrete bed to be laid as the case may be. The top of cross pieces shall indicate different levels such as excavation for pipe line, top of concrete bed, top of the pipe etc. as the case may be.

6.89.11

6.89.12 The sight rail of size 250 mm x 40 mm shall be screwed with the top edge resting against the level marks. The center line of the pipe shall be marked on the rail and this mark shall denote also the meeting point of the center lines of any converging pipes. A line drawn from the top edge of one rail to the top edge of the next rail shall be vertically parallel with the bed of the pipe, and the depth of the bed of pipe at any intermediate point may be determined by letting down the selected boning staff until the tee head comes in the line of sight from rail to rail.

6.89.13

6.89.14 The post and rails shall be perfectly square and planed smooth on all sides and edges. The rails shall be painted white on both sides, and the tee-heads and cross-piece of the boning staves shall be painted black.

6.89.15

6.89.16 For the pipes converging to a manhole/chamber at various levels, there shall be a rail fixed for every different level. When a rail comes within 0.60 M of the surface of the ground, a higher sight-rail shall be fixed for use with the rail over the next point.

6.89.17

6.89.18 The posts and rails shall in no case be removed until the trench is excavated, the pipes are laid and the Engineer gives permission to proceed with the backfilling.

6.89.19

6.89.20 Laying of Pipes and Fittings/Specials

6.89.21

6.89.22 All precautions shall be taken during excavation and laying operations to guard against possible damage to any existing structure/pipeline of water, gas, sewage etc. After excavation of trenches, pipes shall not be lowered unless the dimensions of trenches and bedding work for pipes at the bottom of the trenches are approved and measured by Employer /Engineer. Pipes and fittings/specials shall be carefully lowered in the trenches. Special arrangements such as cranes, tripods with chain pulley block for lowering the pipes and fittings/specials shall be made by Contractor. In no case pipes and fittings/specials shall be dropped. Slings of canvas or equally non-abrasive material of suitable width or special attachment to fit the ends of pipes and fittings/specials shall be used to lift and lower the coated pipes and fittings/specials. The pipes and fittings /specials shall be inspected for defects and be rung with a light hammer preferably while suspended to detect cracks. If doubt persists, further confirmation shall be done by pouring a little kerosene/dye on the inside of the pipe at the suspected spot. No sign of kerosene/dye should appear on the outside surface. Pipes and fittings/specials damaged during lowering or aligning shall be rejected by the Engineer.

6.89.23

6.89.24 All the pipes are to be laid perfectly true both in alignment and to gradient specified. In case of spigot and socket pipe the socket end of the pipe shall face upstream, except when the pipeline runs uphill in which case the socket ends should face the upgrade. The laying of pipes shall always proceed upgrade of a slope. After placing a pipe in the trench, the spigot end shall be centered in the socket and the pipe forced home and aligned to required gradient. The pipes shall be secured in place with approved backfill material tamped under it except at the socket. Pipes and fittings/specials which do not allow a sufficient and uniform space for joints shall be removed and replaced with pipes and fittings/specials of proper dimensions to ensure such uniform space. Precautions shall be taken to prevent dirt from entering the jointing space. At times when pipe laying is not in progress, the open ends of pipe shall be closed by a watertight plug or other means approved by the Engineer. During the period that the plug is on, the Contractor shall take proper precautions against floating of the pipe owing to entry of water into the trench. Wherever it is necessary to deflect pipe from a straight line, either in the vertical or horizontal plane, to avoid obstructions or where long radius curves are permitted the deflection allowed at joints shall not exceed 2 ½0. In case of pipes, with joint to be made with loose collars, the collars shall be slipped on before the next pipe is laid. The pipes shall be laid such that the marking on pipes appears at the top of the pipes.

6.89.25

6.89.26 The cutting of pipe for inserting valves, fittings, or specials shall be done in a neat and workman like manner without damage to the pipe so as to leave a smooth end at right angles to the axis of the pipe. For this purpose, pipe cutting machine shall be used.

6.89.27

6.89.28

6.89.29 Thrust Blocks

6.89.30

6.89.31 Thrust Blocks shall be provided, to counteract hydraulic thrust, at places wherever directed by the Engineer.

6.89.32

6.89.33 Jointing

6.89.34

6.89.35 Jointing for pipes and fittings/specials shall be done in accordance with the relevant Employer's Requirements depending upon the type of pipes being used.

6.89.36

6.89.37 Testing and Commissioning

6.89.38

6.89.39 Testing and commissioning of pipes shall be done in accordance with the relevant Employer's Requirements.

6.89.40

6.89.41 Backfilling

6.89.42

6.89.43 Trenches shall be backfilled with approved selected excavated material only after the successful testing of the pipeline. The tamping around the pipe shall be done by hand or other hand-operated mechanical means. The water content of the soil shall be as near the optimum moisture content as possible. Filling of the trench shall be carried out simultaneously on both sides of the pipe in such a manner that unequal pressure does not occur. Backfilling shall be done in layers not exceeding 30 cm. Each layer shall be consolidated by watering, ramming, care bring taken to avoid damage to the pipeline. In case of the mild steel pipes/specials, the spiders provided during assembly and welding shall be retained until the trench is refilled and consolidated. Where timbers are placed under the pipeline to aid alignment, these timbers shall be removed before backfilling.

6.89.44

6.89.45 The Contractor is requested to provide the method of Backfilling compaction test and evaluation value and obtain the approval from the Engineer.

6.89.46

6.89.47 Reinstatement of Road/Footpath

Reinstatement of road/footpath shall be done as per the requirements of local authorities and the Employer's Requirements after completion of work.

6.89.48 Clearing of Site

All surplus materials, and all tools and temporary structures shall be removed from the site as directed by the Engineer and the construction site left clean to the satisfaction of the Engineer.

6.90 Disinfection of Water Mains

The mains intended for potable water supplies should be disinfected before commissioning them for use. Special care should be take to ensure disinfection of new mains. Among possible sources of contamination are sewer drainage, contaminated soil in the trench, contamination from workmen or their equipment of both and unavoidable foreign material present in the trench during construction.

Education of crew members as to the need for avoiding contamination of the main during construction is fundamental. Contractors and workmen should be thoroughly familiar with all pertinent state and local requirements governing installation of mains. All sewers, water mains and other underground conduits should be located prior to construction relocated, if necessary, to prevent contamination during construction. Pipe should be strung on high ground. At all times when construction is not actually in progress, watertight plugs should be installed in all pipe openings. Gunny sack and rags are not adequate. Provision should be made to pump any other water that might collect in the trench. Special care should be taken to avoid contamination of valves, fittings, and pipe interiors, both before and during construction each of them should be inspected and, if necessary, cleaned before installation.

After pressure testing the main, it should be flushed with clean water at sufficient velocity to remove all dirt and other foreign materials in the constructed pipeline. When this process has been completed, disinfection (using liquid chlorine, sodium or calcium hypochlorite) should proceed by one of the recommended methods as described in the following

6.90.1 Continuous Feed

In this method, water from the distribution system or other approved source and the chlorine is fed at constant rate into the new main at a concentration of atleast 20 mg/1. A property adjusted hypochlorite solution injected into the main with a hypochlorinator, or liquid chlorine injected into the main through a solution feed chlorinator and booster pump may be used. The chlorine residual should be checked at intervals to ensure that the proper level is maintained. Chlorine application should continue until the entire main is filled. All valves, hydrants, etc., along the main should be operated to ensure their proper disinfection. The water should remain in the main for a minimum of 24 hours. Following the 24 hours period no less than 10 mg/1 chlorine residual should remain in the main.

The Contractor is requested to provide photo and take a record the value of chlorine residual at starting point and after 24 hours before completion of work.

The Engineer shall jointly check the test at sites. If the value is insufficient, the disinfections work shall be repeated until satisfactory results are achieved.

Waste chlorine residual water must be neutralized before it is discharged to any drainage.

Slug Method

In this method a continuous flow of water is fed with a constant dose of chlorine (as in the previous method) but with rates proportioned to give a chlorine concentration of at least 300 mg/1. The chlorine is applied continuously for a period of time to provide a column of chlorinated water that contacts all interior surfaces of the main for a period of at least 3 hours. As the slug passes tees, crosses, etc., proper valves shall be operated to ensure their disinfection. This method is used principally for large diameter mains where continuous feed is impractical.

Regardless of the method used, it is necessary to make certain that backflow of the strong chlorine solution into the supplying line does not occur. Following the prescribed contact period, the chlorinated water should be flushed to waste until the remaining water has a chlorine residual approximating that throughout the rest of the system. Bacteriological tests as prescribed by the authorities should be taken, and if the results fail to meet minimum standards, the disinfecting procedure should be repeated and the results again tested before placing the main in service.

If continuous feed method is difficult to apply, Retention Method shall be considered as alternative way.

The area or pipe line to be disinfected shall be fed with chlorine solution from up stream under flowing water condition, and then the area shall be blocked after make sure to reaching more than 20 mg/l. The chlorine solution fed in the pipeline needs to wait for 1 day before starting measurement of residual chlorine. After 3 days later, the chlorine residual value shall be tested at sampling points at up stream and at downstream near to end to check whether the value is in range or not.

The Contractor shall provide photo and take a record the value of chlorine residual at starting point and after 24 hours before completion of work.

The Engineer shall jointly check the test at sites. If the value is insufficient, the disinfections work shall be repeated until satisfactory results are achieved.

Waste chlorine residual water must be neutralized before it is discharged to any drainage, as approved by Engineer.

End of Part 83B